SAFE SYSTEM APPROACH FOR THE URBAN CORE *INFORMATIONAL REPORT*

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

U.S. Department of Transportation
Federal Highway Administration

NOTICE

NON-BINDING CONTENTS

QUALITY ASSURANCE STATEMENT

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16. Abstract

This report outlines how practitioners can apply the principles, elements, and frameworks of the Safe System Approach in policy, program, and project decision-making processes across the urban core through proven safety approaches for urban areas in the United States. A series of checklists is presented to help practitioners understand how to apply the Safe System Approach at a policy, program, and project level, as well as how to apply it to address some of the key challenges that are specific to the urban core environment, such as urban arterials, speed management, urban intersections, and safety of vulnerable road users.

The report includes 10 case studies of noteworthy practices that are relevant to implementing the Safe System Approach in the urban core. Eight of these case studies are from States or cities in the United States, and two are from international locations in Europe and South America that cover multiple locations each. These case studies provide practical examples of how some of the key concepts covered in the report have already been implemented and the benefits that have been realized.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE COVERSIONS TO SI UNITS				
Symbol	**What You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
floz	fluid ounces	29.57	mililiters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERTURE (exact degrees)		
ºF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	ºC
		ILLUMINATION		
fc	foot-candles	10.76	lux	N
fl	foot-Lambers	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE COVERSIONS TO SI UNITS				
Symbol	**What You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
ml	millimeters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short ton (2000lbs)	T
		TEMPERTURE (exact degrees)		
ºC	Celsius	1.8 C+32	Fahrenheit	ºF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.02919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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Executive Summary

There is strong interest in understanding how to apply the Safe System Approach in high-density areas at an area-wide scale that have a mix of vehicle types, land uses, and road users. The Safe System Approach is focused on taking a holistic view of the roadway system and those who use it to anticipate human mistakes and keeping the crash-related kinetic energy impacts on all road users at tolerable levels.

Integrating Safe System principles into transportation projects can lead to more proactive and lasting roadway safety benefits for all users, especially in the urban core, where there are greater numbers of people walking, rolling, and cycling. Information is needed on how roadway owners, operators, and designers can use Safe System principles to help steer decisions that improve safety for all road users over the range of street environments typical in the urban core.

The urban core typically has the greatest density of people in a given area and features a mix of land uses in a block. It is also often characterized by a strong street grid made up of mostly local roads, which are connected to collectors and urban arterials that often bisect the urban core. The Safe System Approach in the urban core should consider a mix of vehicle types, mixed-use development, and diverse road users. Urban core areas have the highest volume of activity, and the patterns of activity are complex. Road users in the urban core include transit users, pedestrians, bicyclists, micromobility users, drivers of service and commercial vehicles, drivers of personal vehicles, and ride share services. This report focuses on prioritizing the safety of all road users on local roads and urban arterials in the densest parts of a community.

Implementing the Safe System Approach in the urban core can also address unique concerns. Right-of-way acquisition and mobilization costs are a deterrent for implementing many types of infrastructure safety projects in dense urban areas. A way to implement the Safe System Approach in the urban core efficiently, then, is to focus on effectively redesigning facilities within the existing right-of-way by applying roadway reconfigurations.

The Safe System Approach is a human-centered approach that anticipates human mistakes and accommodates human vulnerabilities through design and operations that are safer for all road users. Key strategies for implementing the Safe System Approach in the urban core are separation of users in space and time, reduction of crash kinetic energy, and increased attentiveness and awareness. It is important to apply the Safe System Approach equitably to help address structural and institutional racism by correcting for under-investments in historically underserved communities.

This report outlines how practitioners can apply the principles, elements, and framework of the Safe System Approach in policy, program, and project decision-making processes across the entire system through proven safety approaches for urban areas in the United States. A series of checklists are presented to help practitioners understand how to apply the Safe System Approach at the policy, program, and project levels as well as how to apply it to address some of the key challenges that are specific to the urban core context, such as urban arterials in an urban core, speed management, urban core intersections, and safety of vulnerable road users.

The report includes 10 case studies of noteworthy practices that are relevant to implementing the Safe System Approach in the urban core. Eight of these case studies are from States or cities in the United States, and two are from international locations in Europe and South America that cover multiple locations each. These case studies provide practical examples of how some of the key concepts covered in the report have already been implemented and the benefits that have been realized.

Introduction

The Safe System Approach has been embraced by the transportation community as an effective way to address and mitigate the risks inherent in our enormous and complex surface transportation system. It works by building and reinforcing multiple layers of protection to both prevent crashes from happening in the first place and minimize the harm caused to those involved should crashes occur. It is a holistic and comprehensive approach that provides a guiding framework to make places safer for people. This is a shift from a conventional safety approach because it focuses on both human mistakes and human vulnerability as well as system designs with many redundancies in place to protect everyone. The U.S. Department of Transportation (U.S. DOT) has adopted a Safe System Approach as the guiding paradigm to address roadway safety as part of its National Roadway Safety Strategy (U.S. DOT 2022).

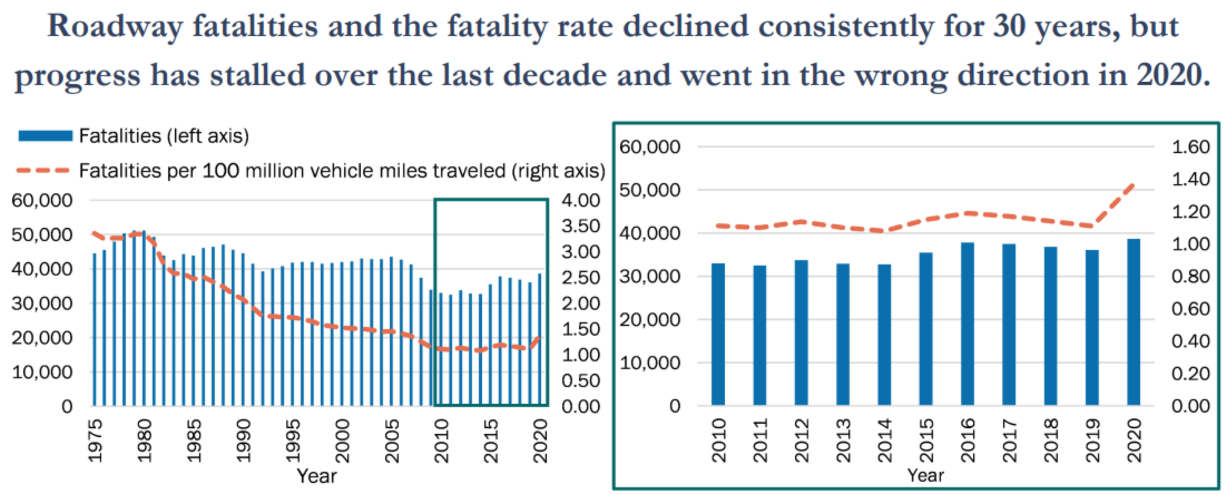
The Safe System Approach is consistent with use of a Complete Streets design model that prioritizes safety, comfort, and connectivity for all users of the roadway. Integrating Safe System principles into transportation projects can lead to more proactive and lasting road safety benefits for all users. This is particularly the case for streets in vibrant communities where there are likely greater numbers of people walking, rolling, and cycling.

The urban core typically includes areas with the highest density, with mixed land uses within and among predominantly high-rise structures. The urban core is mostly found in the central business districts and adjoining portions of major metropolitan areas, where the volume of activity is high and the patterns of activity are complex. Further, road users in the urban core include transit users, pedestrians, bicyclists, micromobility users, drivers of service and commercial vehicles, drivers of personal vehicles, and ride share services. Information is needed on how roadway owners, operators, and designers can use Safe System principles as is a framework to help steer decisions that improve safety for all road users over the range of street environments typical in the urban core.

There are several examples of how the Safe System Approach can be implemented in the urban core; however, a comprehensive resource for practitioners interested in implementing a Safe System Approach to prioritize safety in the urban core is not available. This report synthesizes the existing body of available knowledge on applying the Safe System Approach in the urban core into a usable form for practitioners, including providing key illustrative examples in the form of domestic and international case studies. The goal of this informational report is to help raise awareness, build support, and create pathways for policies and processes that support widespread deployment of the Safe System Approach in the urban core.

Traffic Fatality Trends in Urban Areas in the United States

According to the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS), traffic fatality rates (measured by fatalities per 100 million vehicle miles traveled) have generally declined over the past 30 years until 2010, when they stalled or increased, including a 21-percent increase from 2019 to 2020, as shown in Figure 1. From 2019 to 2020, roadway fatalities in urban areas in particular increased by 8.5 percent for a total of 21,650 deaths on urban roadways in 2020.



Source: National Highway Traffic Safety Administration 2022a.

Figure 1. Chart. Roadway fatality trends compared yearly from 1975 to 2020 per 100 million vehicle miles traveled.

It is important to note that just looking at traffic fatality rates does not explain safety conditions; analyzing a breakdown of the frequency of fatalities by area type, road user type, infrastructure features, demographic characteristics, and other factors is important in implementing the Safe System Approach, described below in further detail. In the United States, the number of roadway fatalities in urban areas has exceeded rural areas since 2016. Additionally, urban roadway fatalities have steadily increased over time, from 14,575 persons killed in urban areas in 2011 to 21,650 persons killed in urban areas in 2020; an increase of 48 percent (National Highway Traffic Safety Administration 2022b). In 2020, an average of 59 persons were killed daily on roads in urban areas in the United States.

A vulnerable road user is generally defined as a person "unprotected by an outside shield, as they sustain a greater risk of injury in any collision with a vehicle and are therefore highly in need of protection against such collisions" (European Conference of Ministers of Transport 2000). For the Highway Safety Improvement Program (HSIP), a vulnerable road user is more narrowly defined as a non-motorist with a FARS person attribute code of: "(5) Pedestrian, (6) Bicyclist, (7) Other Cyclist, and (8) Person on Personal Conveyance" or a pedestrian or a pedalcyclist as defined in the ANSI D16.1-2007 (23 U.S.C. 148(a)(15); 23 CFR 490.205; American National Standards Institute 2007). This report generally considers people walking, biking, and rolling to be vulnerable road users.

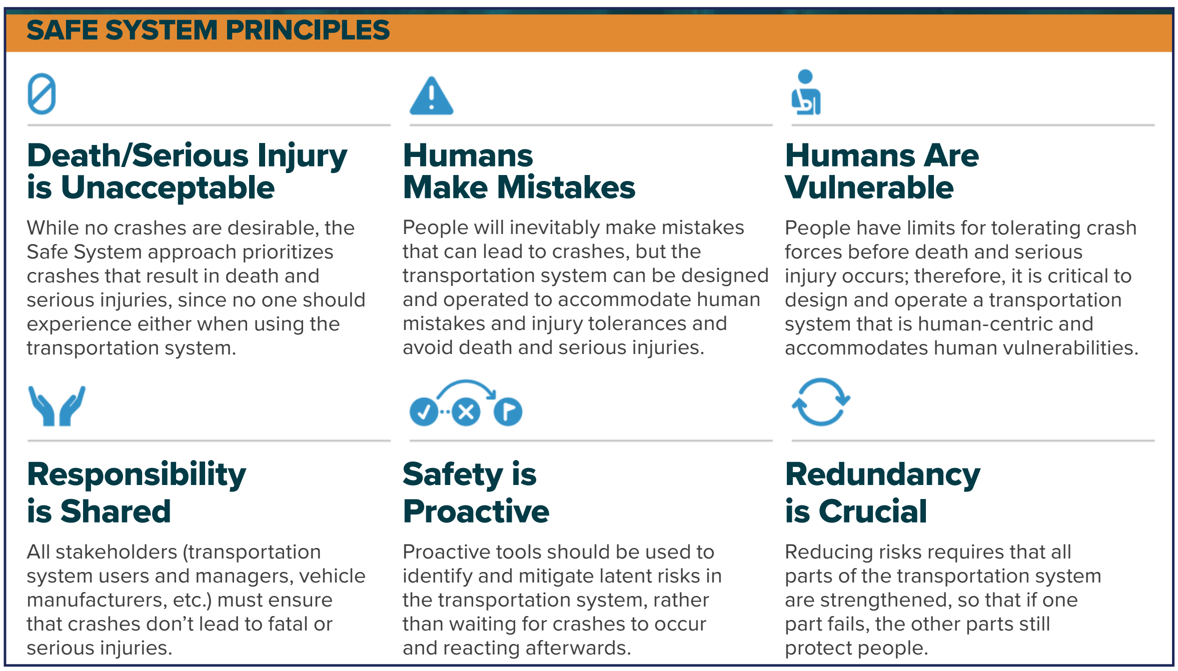
The comparison of traffic fatality composition by person type in the United States over the last decade shows an increase in the proportion of vulnerable road user fatalities. In 2011, the proportion of overall traffic fatalities involving pedestrians, pedalcyclists, and other nonoccupants was 16 percent, increasing to 20 percent in 2020 (National Highway Traffic Safety Administration 2022b). The potential for conflicts and crashes increases in urban areas due to the increased number of road users—including vulnerable road users—and the overall amount of activity. According to the Insurance Institute for Highway Safety (IIHS), the rate of fatalities per 100 million miles traveled in urban areas was 0.86 in 2019 compared to 1.66 in rural areas for all road users; however, more than 70 percent of pedestrian and bicyclist fatalities occurred in urban areas. (Insurance Institute for Highway Safety 2021).

The Safe System Approach

The Safe System Approach is human-centered. It is founded on the ethical imperative that road fatalities and serious injuries must be eliminated, that humans make mistakes, and that humans have limited ability to withstand kinetic energy forces due to crashes. The adoption of the Safe System Approach by the transportation community represents a shift away from a reactive traditional safety approach toward the understanding that road fatalities and serious injuries result not only from human behavior, but also from the transportation system itself. The Safe System Approach seeks safety through the use of vehicle, human, and roadway design and operational changes rather than relying primarily on human behavior for safety.

The Safe System Approach is a drastic shift towards ensuring safety and should be proactively incorporated in all decisions across the built environment and the way we move.

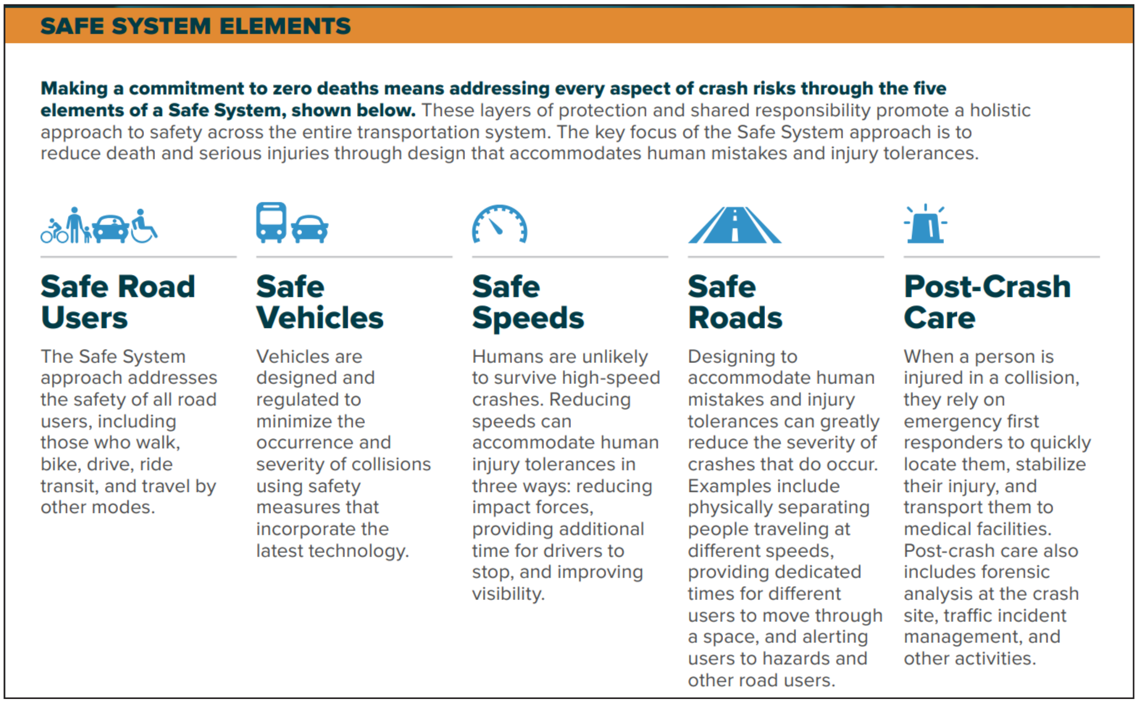
In a Safe System Approach, the transportation system is designed and managed to prevent fatal and serious injury crashes from happening and to minimize the harm caused to those involved should crashes occur. The basis of the Safe System Approach is formed by the six principles illustrated in Figure 2.



Source: FHWA2020b.

Figure 2. Graphic. The principles of the Safe System Approach.

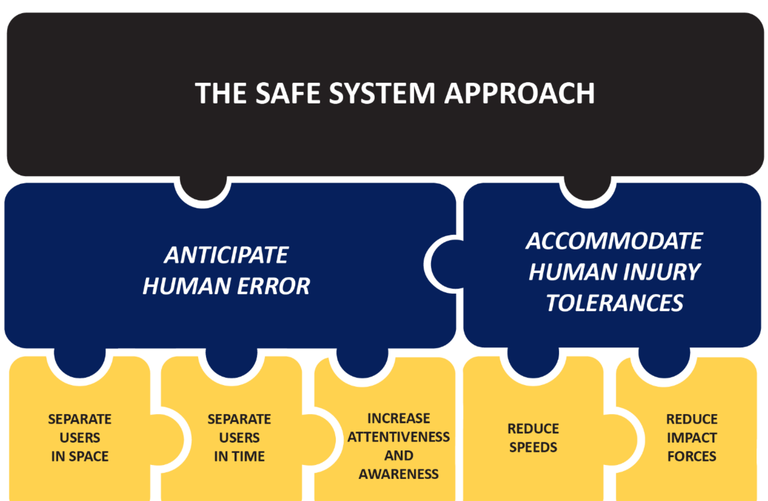
The Safe System Approach minimizes severe crash risk through the strengthening of all five elements: safe road users, safe vehicles, safe speeds, safe roads, and post-crash care, as shown in Figure 3. When these elements are incorporated in all decision-making processes, from policy to design decisions, roadway systems become safer for all users.



Source: FHWA 2020b.

Figure 3. Graphic. The Safe System Approach elements.

The Safe System Approach framework illustrated in Figure 4 provides a framework for applying the Safe System Approach with a focus on the most relevant elements—safe roads and safe speeds—through roadway policy, design, operations, and maintenance decisions across the transportation system. It addresses two of the six Safe System Approach principles: to anticipate human error and to accommodate human injury tolerances. Anticipating human error includes separating users in space and time, increasing attentiveness and awareness, and reducing impairment in a proactive and redundant way. Accommodating human injury tolerances includes reducing speed and impact forces by considering kinetic energy impacts of all road users. The decisions for prioritizing safety using the Safe System Approach should always be weighted so that if a crash occurs, it does not result in a fatal or serious injury (Institute of Transportation Engineers 2019).



Source: FHWA n.d.

Figure 4. Graphic. The Safe System Approach Framework.

The Safe System Approach has interconnections with concepts such as context sensitive design solutions, Complete Streets, and self-enforcing/self-explaining roads. FHWA's report *Moving to a Complete Streets Design Model: A Report to Congress on Opportunities and Challenges* states: "The first core principle of context-sensitive design is to ensure that the project provides safety for all users" (Federal Highway Administration 2022e).

CONTEXT SENSITIVE DESIGN

Context sensitive design is a collaborative, interdisciplinary decision-making process and design approach that involves all stakeholders to develop a transportation facility that fits its physical setting. According to FHWA (2018), context sensitive design ensures the following:

- Safety for all users
- Use of a shared stakeholder vision as a basis for decisions and for solving problems that may arise
- Expectations of both designers and stakeholders are met or exceeded, thereby adding lasting value to the community, the environment, and the transportation system
- Effective and efficient use of resources

The 2021 Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law (BIL) defines Complete Streets standards or policies as those which "ensure the safe and adequate accommodation of all users of the transportation system, including pedestrians, bicyclists, public transportation users, children, older individuals, individuals with disabilities, motorists, and freight vehicles." (Pub. L. No. 117-58, § 11206(a)). Additionally:

> A Complete Streets Design Model prioritizes safety, comfort, and connectivity for all users of the roadway, including but not limited to pedestrians, bicyclists, motorists, and transit riders of all ages and abilities. In general, this design model includes careful consideration of measures to set and design for appropriate speeds; separation of various users in time and space; improvement of connectivity and access for pedestrians, bicyclists, and transit riders, including for people with disabilities; and implementation of safety countermeasures. Use of the design model is determined by context. FHWA recommends the application of a complete streets design model on roadways where adjacent land use suggests that trips could be served by varied modes, and to achieve complete travel networks for various types of road users. (Federal Highway Administration 2022f)

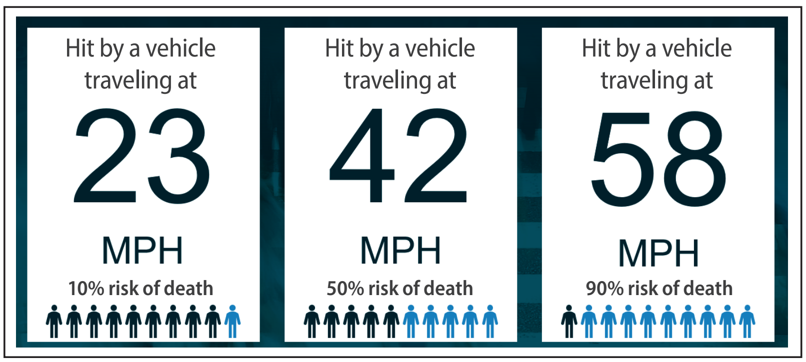
SELF-ENFORCING OR SELF-EXPLAINING ROADS

Self-enforcing or self-explaining roads are those roadways designed with features to indicate to drivers what the safe and appropriate operating speed is for the safety of all road users (Federal Highway Administration 2018b). An operating speed that is safe and appropriate for the conditions of a given road may also be called a target speed. Target speed is defined as the highest operating speed at which vehicles should ideally operate on a roadway in a specific context (American Association of State Highway and Transportation Officials 2018).

Context sensitive design, Complete Streets, and self-enforcing or self-explaining roads are example concepts for implementing the safe roads element of the Safe System Approach.

KINETIC ENERGY FORCES AND THE SAFE SYSTEM APPROACH

Kinetic energy forces cause injury to the human body in the event of a crash. When kinetic energy forces exceed tolerable thresholds, a fatal or serious injury occurs. With the goal of zero traffic deaths in mind, the Safe System Approach framework seeks to accommodate human injury tolerances by reducing speeds and impact angles. This involves evaluating how to design roadways through an injury minimization perspective. However, injury minimization and reducing kinetic energy forces must be done in a way that considers all road users, especially those without the protection provided by a vehicle. According to the 2011 study on *Impact Speed and a Pedestrian's Risk of Severe Injury or Death*, the "average risk of death for a pedestrian reaches 10% at an impact speed of 23 mph, 25 percent at 32 mph, 50 percent at 42 mph, 75 percent at 50 mph, and 90 percent at 58 mph," and the difference between a serious injury to and fatality of a pedestrian is only about 10 miles per hour (AAA Foundation for Traffic Safety 2011). This relationship is illustrated graphically in Figure 5.



Source: FHWA 2023 based on data from AAA Foundation for Traffic Safety 2011.

Figure 5. Graphic. Risk of death based on vehicle speeds.

SUCCESS WITH THE SAFE SYSTEM APPROACH INTERNATIONALLY

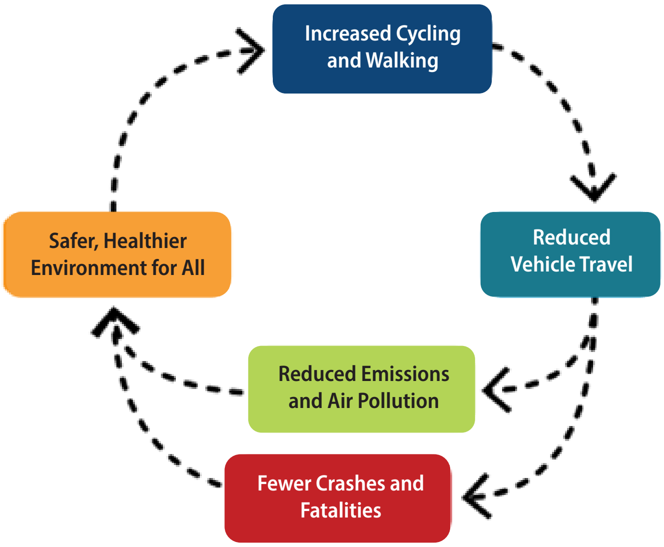
The Permanent International Association of Road Congresses (PIARC) identifies the Safe System Approach as "the most effective way of considering and responding to fatal and serious casualty crash risks on a network" (World Road Association 2019).

According to the *Sustainable and Safe* report from the World Resources Institute (WRI), countries that have applied the Safe System Approach have achieved both the lowest rates of fatalities per 100,000 inhabitants and the greatest reduction in fatality rates over the past 20 years (World Resources Institute 2018). From 1994 to 2015, these countries experienced a reduction in road fatalities between 50 percent and 70 percent, as shown in Figure 6. As previously discussed, traffic fatality rates in the United States have generally declined over the past 30 years until 2010 when they stalled or increased.

Source: FHWA 2023 based on data from WRI 2015.

Figure 6. Graphic. Statistics on the Safe System Approach in Sweden, the Netherlands, Australia, and New Zealand.

The Safe System Approach originated in the 1990s in Sweden as Vision Zero and in the Netherlands as Sustainable Safety. Both models had common foundations based on ensuring safety for all road users and the need for transportation professionals to design the system to reduce the risk of fatal and serious injury crashes (Bicycle Dutch 2017). This model required a systemic and radical shift in these countries away from car-oriented development towards human-centered design and took nearly a decade to achieve the reductions. The shift included understanding how people were moving and where people were going to create a safer system. The graphic shown in Figure 7 outlines how the Safe System Approach can incrementally improve safety and also provide environmental and health benefits.



Source: WRI 2015.

Figure 7. Graphic. Improving safety using the Safe System Approach also improves the entire system.

The international implementations of the Safe System Approach or Sustainable Safety have taken a critical look at the impacts of the built environment and road designs on crashes, rather than focusing solely on human behavior (World Resources Institute 2018). In Utrecht, Netherlands, city planning policies were changed in the early 1990s along with systemic implementation of Sustainable Safety. These institutionalized policies now require separated bicycle facilities for connecting key destinations, removal of parking in the center of the city, and limiting trips through the city center. Figure 8 is an image of the transformation in Utrecht, Netherlands, once Sustainable Safety was applied across the network.

Source: FHWA 2017.

Figure 8. Image. Before and after photos of Catharijnesingel in Utrecht, Netherlands between 2000 and 2018.

Australia and New Zealand have also applied the Safe System Approach nationally and seen reductions in roadway fatalities, through the Safe System and Safer Journeys program respectively (World Resources Institute 2018). All four leading countries in roadway safety that have committed to systemically applying the Safe System Approach have looked at their nationwide leading crash contributing factors and have implemented new policies and guidance to support transportation professionals prioritizing safety. For example, Austroads, a collective of Australian and New Zealand transportation agencies, has created a Guide to Road Safety that provides recommendations on how to apply the Safe System Approach in application (Austroads 2022).

Australia also has an Australian Road Assessment Program (AusRAP) that applies the Safe System Approach through Safer Roads Investment Plans (SRIPs) to systematically apply effective countermeasures that will contribute toward a reduction in the number of people being killed or seriously injured on Australia's national highways that operate at 90 km/h (56 mph) or greater. The AusRAP ratings are based on the International Road Assessment Program (iRAP) methodology. Ratings were completed and published on all Australian national highways and the lowest 1-star rated roadway segments are prioritized for increased safety improvements (Australian Automobile Association (AAA) 2013). The iRAP methodology is used by more than 100 countries worldwide to inspect high-risk roads and develop star ratings, risk maps, and SRIPs (International Road Assessment Programme n.d.). The United States also has a United States Road Assessment Program (usRAP) modeled after iRAP methods that utilizes proactive risk assessment, mapping, readily available data, and reliable cost-benefit considerations to help agencies of all sizes develop SRIPs (United States Road Assessment Program n.d.).

SHIFTING FROM TRADITIONAL SAFETY TO THE SAFE SYSTEM APPROACH

The Safe System Approach offers a lens through which transportation professionals can think about increasing safety in a way that prevents fatalities and serious injuries. This is a shift from traditional roadway safety thinking.

The Safe System Approach prioritizes safety in transportation decision making and applies an evidence-based method for dedicating resources to systemic safety improvements for all road users. FHWA builds on zero deaths goals by stating that zero is the goal, and the Safe System Approach is how we get there (Federal Highway Administration 2020). Community-based Vision Zero goals were adopted for the first time in the United States by the city of Chicago in 2012, and now more than 50 agencies are setting the goal of reducing and ultimately eliminating traffic deaths (Pedestrian and Bicycle Information Center n.d.). The Washington State Department of Transportation was one of the first agencies to recognize and implement the Safe System Approach, and now agencies all over the United States are beginning to apply it (Washington State Department of Transportation 2019).

Adopting the principles, elements, and framework of the Safe System Approach is a first step in working toward an ambitious long-term goal of zero roadway fatalities and serious injuries. Both the Safe System Approach and a long-term goal of zero roadway fatalities and serious injuries are included in U.S. DOT's *National Roadway Safety Strategy* in January 2022 (United States Department of Transportation 2022). Figure 9 shows how to shift from traditional road safety practices to the Safe System Approach.

Source: FHWA 2020b.

Figure 9. Graphic. Shift from traditional safety toward the Safe System Approach.

The Safe System Approach proactively identifies safety risks and takes a systemic approach to lowering risk, and eventually eliminating risk, with a goal of preventing future fatal and serious injury crashes. This requires a shift from improving human behavior to proactively designing roadways in urban areas that prevent fatal and serious injuries should a crash occur. Shared responsibility and ensuring redundancy in the system are key to applying the Safe System Approach in an urban area.

According to U.S. DOT's *National Roadway Safety Strategy*, "to achieve zero roadway fatalities and a transportation system that is safe for all users, all actors in our transportation system must acknowledge and address historic and ongoing inequities" (United States Department of Transportation 2022). Underserved populations are disproportionately affected by roadway crashes. For example, in the city of Minneapolis, Minnesota, the highest number of crashes occurs in the lowest income neighborhoods—identified as Areas of Concentrated Poverty (ACPs), census tracts where 40 percent or more of the residents have family or individual incomes that are less than 185 percent of the Federal poverty threshold.

Therefore, any application of the Safe System Approach should consider both safety and equity to ensure the system is safe for everyone, and that may include dedicating more resources toward improving safety in neighborhoods that have been marginalized and safety risk is higher (City of Minneapolis n.d.).

The BIL provides increased Federal funding for Complete Streets (see BIL § 11206) and the safety of vulnerable road users (*see* BIL § 11111), providing an unprecedented ability to apply the Safe System Approach—especially in urban cores across the country. Discretionary programs, like the Safe Streets and Roads for All Discretionary Grant Program, provide additional conduits for applying the Safe System Approach principles and framework directly to urban areas and using methods outlined later in this report.

The Urban Core Context

According to the nonregulatory AASHTO *Policy on Geometric Design of Highways and Streets, 7th Edition*, the urban core context is defined as:

> Areas of the highest density, with mixed land uses within and among predominantly high-rise structures, and with small building setbacks. The urban core context is found predominantly in the central business districts and adjoining portions of major metropolitan areas. On-street parking is often more limited and time restricted than in the urban context. Substantial parking is in multi-level structures attached to or integrated with other structures. The area is accessible to automobiles, commercial delivery vehicles, and public transit. Sidewalks are present nearly continuously, with pedestrian plazas and multilevel pedestrian bridges connecting commercial and parking structures in some locations. Transit corridors, including bus and rail transit, are typically common and major transit terminals may be present. Some government services are available, while other commercial uses predominate, including financial and legal services. Structures may have multiple uses and setbacks are not as generous as in the surrounding urban area. Residences are often apartments or condominiums. Driver speed expectations are low, and pedestrian and bicycle flows are high. (American Association of State Highway and Transportation Officials 2018)

The urban core typically has the greatest density of people in a given area with a mix of land uses in a block. It is often characterized by a strong street grid made up of mostly local roads that feed back to collectors and urban arterials that often bisect the urban core. This informational report predominately focuses on prioritizing safety on local roads and urban arterials in the densest parts of a community; however, all functional road classifications sometimes impact urban areas in communities depending on the way the community was developed and how transportation systems were integrated.

Local roads and collectors are usually the most common by mileage, but urban arterials are often the most common road type for fatalities and serious injuries. Urban arterials, and in some cases highways, running through cities can cause major safety issues, including higher speeds and bisecting and cutting off key parts of an urban area from one another (Schwartz 2015).

According to the 2015 WRI report *Cities Safer by Design: Urban Design Recommendations for Healthier Cities, Fewer Traffic Fatalities*, creating a safer environment can include connected and compact urban design, safer vehicle speeds, designing and operating arterials for the safety of all road users, and encouraging walking, rolling, and taking transit by considering block size, street connectivity, street widths, access to destinations, and population density (World Resources Institute 2015). Additionally, prioritization of vulnerable road users in urban areas can be shown to increase the safety of all road users across the system (United Kingdom Department of Transport 2022).

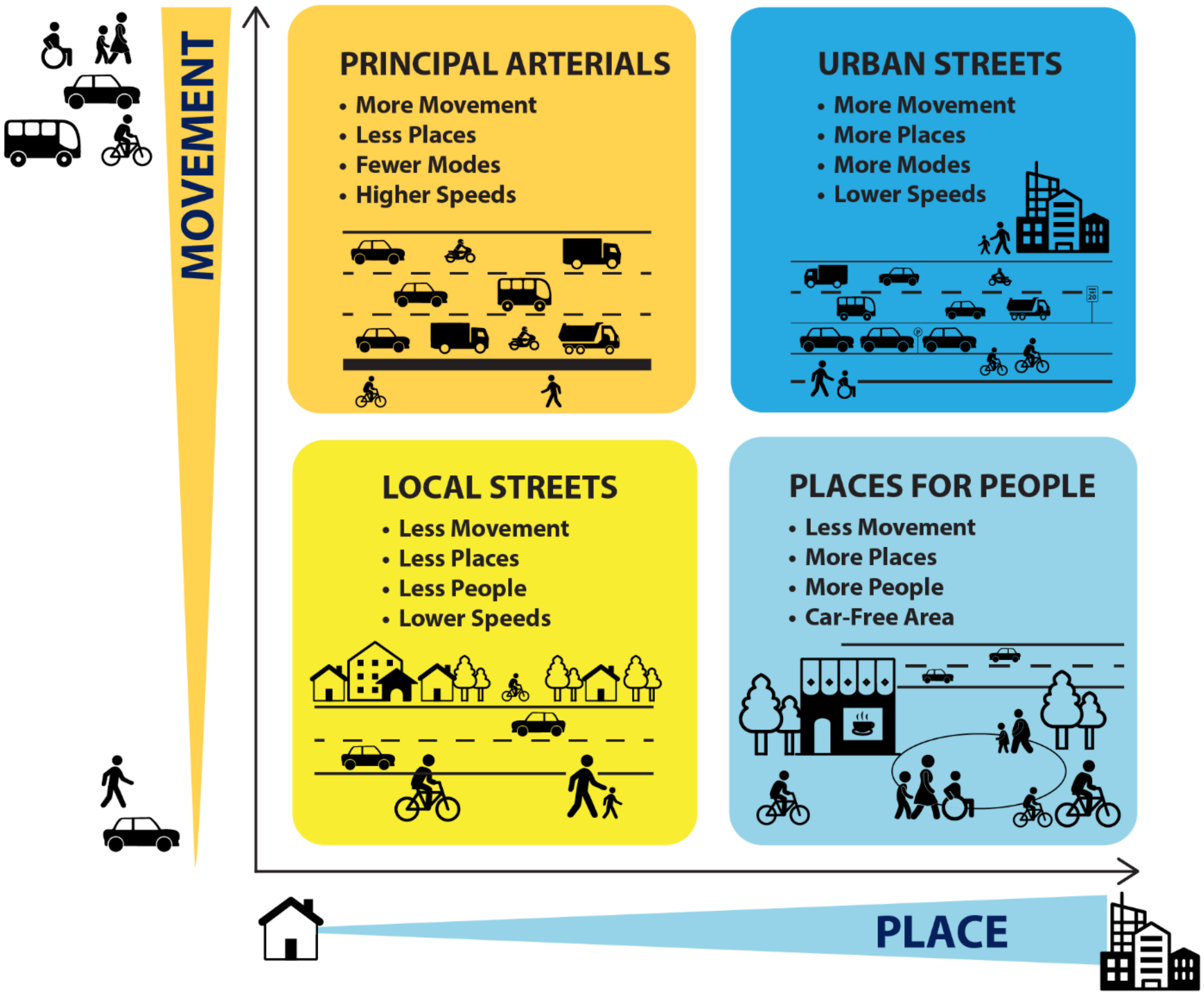
SUSTAINABLE SAFETY

Prior to the expansion of context zones by the American Association of State Highway and Transportation Officials (AASHTO), cities in the United States and internationally were using various schemes to prioritize safety of vulnerable road users in high-density/high-activity areas. Sustainable Safety, founded in the Netherlands in 1997, is an example of a method that incorporated a few Safe System Approach principles. Sustainable Safety considers three elements: the functionality of roads, predicting traffic flows, and the balance of volume and speed (Harirchian, Esmaeili and Kermanshahi 2018). Under the concept of Sustainable Safety, the National Association of City Transportation Officials (NACTO) identified the following 10 components to Sustainable Safety in the *Global Streets Design Guide* (National Association of City Transportation Officials 2016):

1. Streets for everyone (Inclusive Design for children, seniors, and people with disabilities)
2. Streets are multidimensional spaces (People experience with all their senses)
3. Streets for safety (Design to be safe and comfortable for all users)
4. Streets for health (Support healthy environments and lifestyle choices)
5. Streets are public spaces (A place for cultural expression, social interaction, and public demonstration)
6. Streets as ecosystems (Improve the biodiversity and quality of urban ecosystems)
7. Streets for context (Support current and planned contexts and multiple scales)
8. Streets are multimodal (Design for a range of mobility choices)
9. Great streets, Great values (To be an economic asset as well as a functional element)
10. Streets can change (Allowing people to experience the streets differently)

MOVEMENT AND PLACE FRAMEWORK

Another method that incorporates Safe System Approach elements and prioritizes safety of all road users in urban areas began in Australia and is known as Movement and Place. The Movement and Place framework is similar to context sensitive design and solutions in the United States but provides more specific information on the safety considerations in roadway and land use. The functions of public rights-of-ways include facilitating the movement of people and goods on roadways or being places for people to gather on sidewalks and plazas. The Movement and Place method of the Safe System Approach effectively prioritizes safety over movement based on the hierarchy of the road type and road users. It prioritizes reducing potential conflicts and facilitates safe and timely movement of all people, not just cars. The Movement and Place framework has been adapted to context and functional road types in the United States, as shown in Figure 10.



Source: FHWA.

Figure 10. Graphic. Movement and Place Framework.

In the case of urban arterials, referred to as movement corridors in the Movement and Place framework, applying the Safe System Approach for separating uses in space may require installation of above- or below-grade facilities to ensure the safety of vulnerable road users who may need to cross a road with higher speeds and volumes. This type of separation in space also ensures that portions of urban areas are not disconnected from each other.

The Road Cross-section Design for Road Stereotypes (including Network Safety Plans) and a Safe System from Austroads provides a framework to apply the Movement and Place method as well as other applicable practices using the Safe System Approach in the United States (Aumann et al. 2020). Additional information on the Movement and Place framework can be found through the government of New South Wales, Australia by visiting: https://www.transport.nsw.gov.au/industry/nsw-movement-and-place-framework.

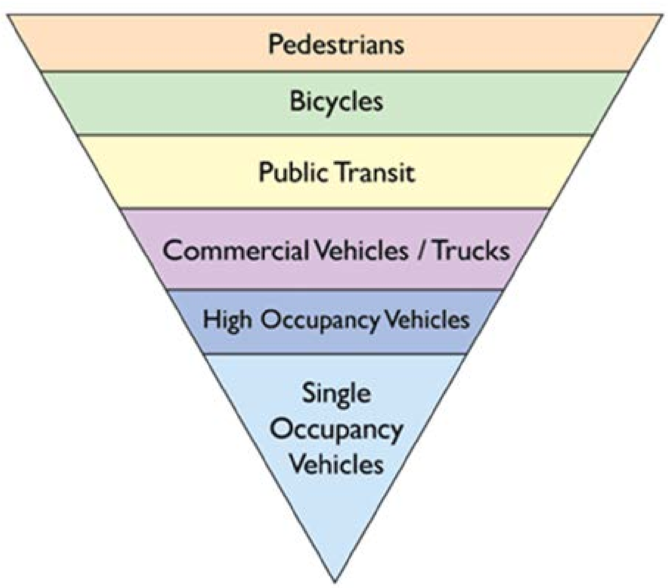
Similarly, the *Integrating Human Health into Urban and Transport Planning* book includes a chapter entitled "Urban form and road safety: Public and active transport enable high levels of road safety," which highlights the 5Ds method to the Safe System Approach to road safety (Schepers, Lovegrove, and Helbich 2019). The 5Ds are density, diversity, design, distance to transit, and destination accessibility. The authors conclude that:

> Increased volumes of walking and cycling are associated with reduced vehicular operating speeds as driver awareness of pedestrians and cyclists increases. Increased active transport volumes are also likely to increase public support for protected neighbourhood cores, area-wide traffic calming, and comprehensive pedestrian and cycling networks. Moreover, dense and diverse land uses enable more community finances to be invested in (sustainably) safer transport systems such as metro and rail. Achieving higher levels of road safety and public health requires a 'bottom-up' design process of development patterns that focus on the human-scale needs of pedestrians and cyclists first, supported with convenient, high-quality public transport, services, and parks. Only in the last stages should motor traffic be carefully designed for, and then only as a "guest" to this otherwise sustainability-oriented community.

It should be noted that many countries that applied a systemic approach to safety through the Safe System Approach also made significant shifts in investments for pedestrian and bicycle infrastructure to separate road users in space and time across the system, increase access using active modes, and minimize dependency on vehicle trips.

SAFETY OF VULNERABLE ROAD USERS AS A PRIORITY IN THE UNITED STATES

Some agencies in the United States have also applied similar safety prioritizations for vulnerable road users, called modal hierarchy. For example, the city of Bellingham, Washington, has a policy to "[d]esign multimodal transportation improvements on existing and new streets with the safety and mobility needs of all user groups considered and with priority emphasis placed on the most vulnerable user groups" and uses the modal hierarchy chart shown in Figure 11 for prioritizing road user safety.



Source: City of Bellingham, Washington, 2016.

Figure 11. Graphic. Modal roadway safety hierarchy based on vulnerability to safety risk.

The Safe System Approach and the Urban Core Considerations

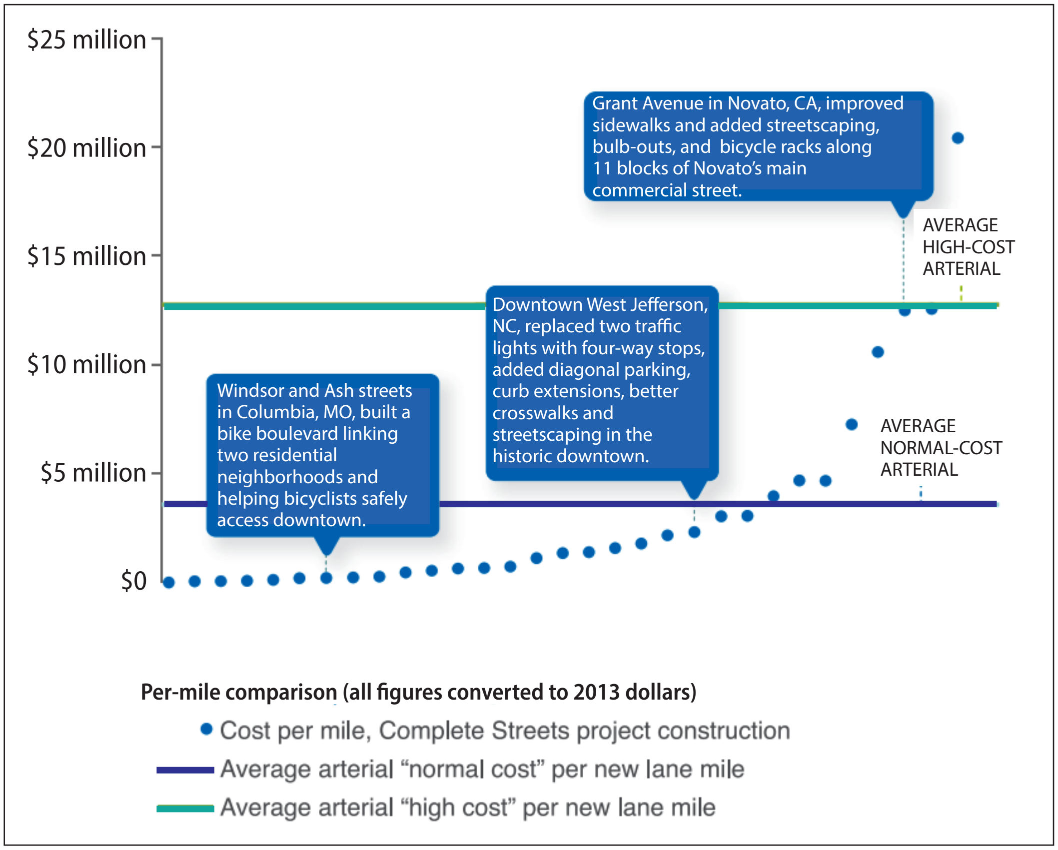
The principles and elements of the Safe System Approach are the same for every context; however, the activity level, road user types, and conflicts are specific to each context. The Safe System Approach in the urban core should consider a mix of vehicle types, mixed-use development, and diverse road users. Urban core areas have the highest volume of activity, and the patterns of activity are complex. Road users in the urban core include transit users, pedestrians, bicyclists, micromobility users, drivers of commercial and service vehicles, drivers of personal vehicles, and ride share services. Due to the dense development, high level of road conflicts, and presence of vulnerable users, the focus when applying the Safe System Approach in the urban core should be to lower the kinetic energy of crash impacts and separate users in time and space. Due to the complexity of the urban core, implementing the Safe System Approach can inform processes for implementing the approach in other contexts.

POTENTIAL CONCERNS

One of the potential concerns practitioners may face when implementing the Safe System Approach in the urban core is roadway ownership. Most roads in the urban core roads are owned and maintained by cities; however, some urban core roads may be part of the State highway system. To implement projects along roads that are part of the State highway system, a city can apply for roadway relinquishment, which is typically a multi-year process that usually involves State legislative approval. More commonly, a city coordinates with State DOTs, which can share and provide safety funds (e.g., HSIP) to implement project improvements. Collaboration among State and local agencies, metropolitan planning organizations (MPOs), traffic safety advocates, partners, and stakeholders is needed to recognize the implications of policy making in all areas of the transportation system and to implement the Safe System Approach. As an example, the Vision Zero efforts in the city of Fremont, California, called for redesigning high-speed streets in the urban core; however, State Route 84 was owned by the State and was not aligned to the city of Fremont's vision. Following a multi-year process, Fremont secured relinquishment of the section of State Route 84 in the urban core, which is planned to be redesigned as part of a Complete Streets project (City of Fremont 2021). A full Fremont case study is included in the appendix.

States, local jurisdictions, MPOs, and other safety partners can also coordinate to maximize the reach of safety efforts and programs to the local communities in the urban core. As an example, the Washington Traffic Safety Commission (WTSC) funds and supports a statewide network of 17 Target Zero Managers (TZMs) who are involved in the coordination and fiscal management of WTSC's grant-funded projects. TZMs guide local task forces composed of engineering, enforcement, education, and emergency medical services (EMS) experts, as well as other community agencies and organizations with an interest in traffic safety. The TZMs and task forces coordinate local traffic safety efforts and resources by tracking data, trends, and issues in their area. They develop and provide a variety of traffic safety programs, services, and public outreach throughout their communities by working with local partners. The engagement of TZMs and local jurisdictions resulted in a reduction of injury crashes in the urban core in Seattle and Bellevue (State of Washington 2019).

Right-of-way acquisition and mobilization costs are also a deterrent for implementing many infrastructure projects in dense urban areas. This means that implementing the Safe System Approach in the urban core may need to focus on effectively redesigning facilities within the existing right-of-way by applying roadway reconfigurations, such as converting vehicular travel lanes into bike lanes. For the most part, improvements based on the Safe System Approach elements and principles cost significantly less than conventional transportation projects (Smart Growth America 2015). Figure 12 shows the comparison of typical construction costs per mile of Complete Streets projects and urban arterial projects. Most Complete Streets improvements cost less than an urban arterial, with a few projects showing no additional cost to the jurisdiction. The projects that cost "zero dollars" are examples of how pedestrian and bicycle improvements can be included in existing projects, such as incorporating bike lanes into existing resurfacing projects by reducing vehicular travel lane widths.



Source: Smart Growth America 2015.

Figure 12. Graph. Cost per mile to build Complete Streets projects vs. an average arterial road.

Reducing speed limits and removing vehicular lanes to create roadway separation for pedestrians and bicyclists may cause concerns regarding congestion, travel time, and increased intersection delay. However, studies have found that average road speeds in urban settings are more determined by the frequency of intersections than speed limits (Sharpin, et al. 2017) and that a lower speed limit only adds a few seconds of travel time between intersections (Ville de Grenoble 2015). Further, there is evidence that travel speeds and traffic volumes typically remain steady with the addition of protected bicycle lanes along corridors (New York City Department of Transportation 2014).

Business owners are typically concerned that the reduction of speeds, reduction of automobile travel lanes, and reduction of the number of parking spaces may reduce automobile traffic and, consequently, reduce business visits. However, studies show that non-motorized users are competitive consumers as they visit the neighborhood the most often and account for the majority of retail dollars spent in the urban core area (Clifton et al. 2013; Transportation Alternatives 2012). Further, there is evidence that removing on-street parking and travel lanes may not hurt businesses. After the removal of parking spaces for installation of a bicycle climbing lane, the business district at NE 65th Street and Latona Avenue NE in Seattle experienced an increase in sales (Rowe 2013). Similarly, after a Road Diet (conversion from four to two travel lanes and addition of bike lanes in both directions) was implemented along Magnolia Street in Fort Worth, restaurant revenues increased (Blue 2016).

Overall, Safe System Approach improvements can make streets more desirable for all road users and lead to improved quality of life and increased economic development (Smart Growth America 2015). Although challenges and concerns may arise following the implementation of the Safe System Approach in the urban core, educating the public on the need to eliminate road fatalities and serious injuries is key, especially regarding the safety of vulnerable road users.

PRIORITIZING SAFETY AND SAFE MOBILITY

In the urban core, going to work, stores, doctors, houses of worship, school, or social functions does not necessarily mean getting into a car. A mobile society also implies transportation choices, so that people of all ages and abilities have access to travel mode options. Therefore, mobility should not be defined by how many vehicle miles are traveled or solely measured in terms of travel times, level of traffic congestion, or duration of congestion. Rather, mobility also can be measured in terms of the availability of travel choices, which may include different routes or modes of travel, such as transit, bicycling, and walking (Federal Highway Administration 2003).

Practitioners can implement the Safe System Approach in the urban core by shifting the focus to providing safe mobility for all road users, especially the most vulnerable. The design of Safe System roads accommodates predictable human limitations and behavior so that human mistakes do not lead to death or serious injury. Roads should be designed to limit crash forces to survivable levels. Safe System project investments should be applied equitably, proactively, and systemically.

Road safety is inextricably linked to mobility, access, equity, and many other transportation values and objectives. Practitioners should find a balance on how to provide multiple mobility options while ensuring safety for users of every transportation option. Safe System Approach projects, such as on-street bicycle lanes, off-street trails, and improved sidewalk connectivity, may not measurably decrease congestion levels, but they provide safe alternatives to driving and can provide access to non-drivers, including children, to reach employment, schools, parks, libraries, and other facilities. Practitioners should prioritize safety and safe mobility for all users, even if that results in a decrease in vehicle throughput (National Association of City Transportation Officials 2016).

IMPORTANCE OF EQUITY AND SAFETY IN THE SAFE SYSTEM APPROACH

Along with safety, equity should be a key consideration in every transportation decision that is made. *Executive Order 13985* defines equity as “consistent and systematic fair, just, and impartial treatment of all individuals” (The White House 2021). Equity also includes ensuring that all segments of populations are heard in the community engagement process.

In the urban core, historical transportation and land use decisions such as redlining, urban renewal, and the Interstate Highway Act, have led to separation and marginalization of segments of populations that still persist today. These inequitable decisions led to segregated urban areas that have resulted in concerning safety and equity statistics. For example, the *2022 Dangerous by Design* report notes arterials in low-income communities of color have a higher frequency of pedestrian fatalities (Smart Growth America and National Complete Streets Coalition 2022). The Governors Highway Safety Association report *An Analysis of Traffic Fatalities by Race and Ethnicity* (2021) notes those living in large central metropolitan areas had the highest pedestrian death rates according to Centers for Disease Control and Prevention National Vital Statistics System from 2001-2010. From the same report and data, American Indian/Alaskan Native populations and Hispanic and Black males had the highest pedestrian death rates. Implementing the Safe System Approach in the urban core should include ways to correct the equity disparities and unsafe road conditions of the past. U.S. DOT's implementation of the Justice40 initiative provides equity data sources such as the *Transportation Disadvantaged Census Tracts* mapping tool and data from the *United States Census Bureau American Community Survey* that are important to identify underserved populations and areas in the urban core (Federal Highway Administration 2022).

Incorporating equity into safety analysis means working with individuals in underserved communities to accomplish the following:

- Collect and analyze data to identify communities experiencing disparities in roadway fatalities and serious injuries.
- Engage community representatives to understand their transportation safety needs and build trust.
- Implement improvements in safety planning, funding, design, operations, and maintenance processes to eliminate disparities in traffic fatalities and serious injuries.
- Evaluate impacts by monitoring outcomes and working to continuously improve outcomes with communities.

How Key Existing Resources Relate to the Safe System Approach in the Urban Core

Because the Safe System Approach remains a relatively new concept in the United States, use of the Safe System Approach is not yet well represented in key foundational references that are used daily by transportation professionals. However, many of the basic building blocks of the Safe System Approach are included in these references as summarized below:

FHWA PROVEN SAFETY COUNTERMEASURES

FHWA's Proven Safety Countermeasures (PSCs) initiative is a set of countermeasures and strategies effective in reducing roadway fatalities and serious injuries on highways (Federal Highway Administration 2021). Transportation agencies are strongly encouraged to consider widespread implementation of PSCs to accelerate the achievement of local, State, and national safety goals. Currently there are 28 countermeasures identified as PSCs, as shown in Figure 13.

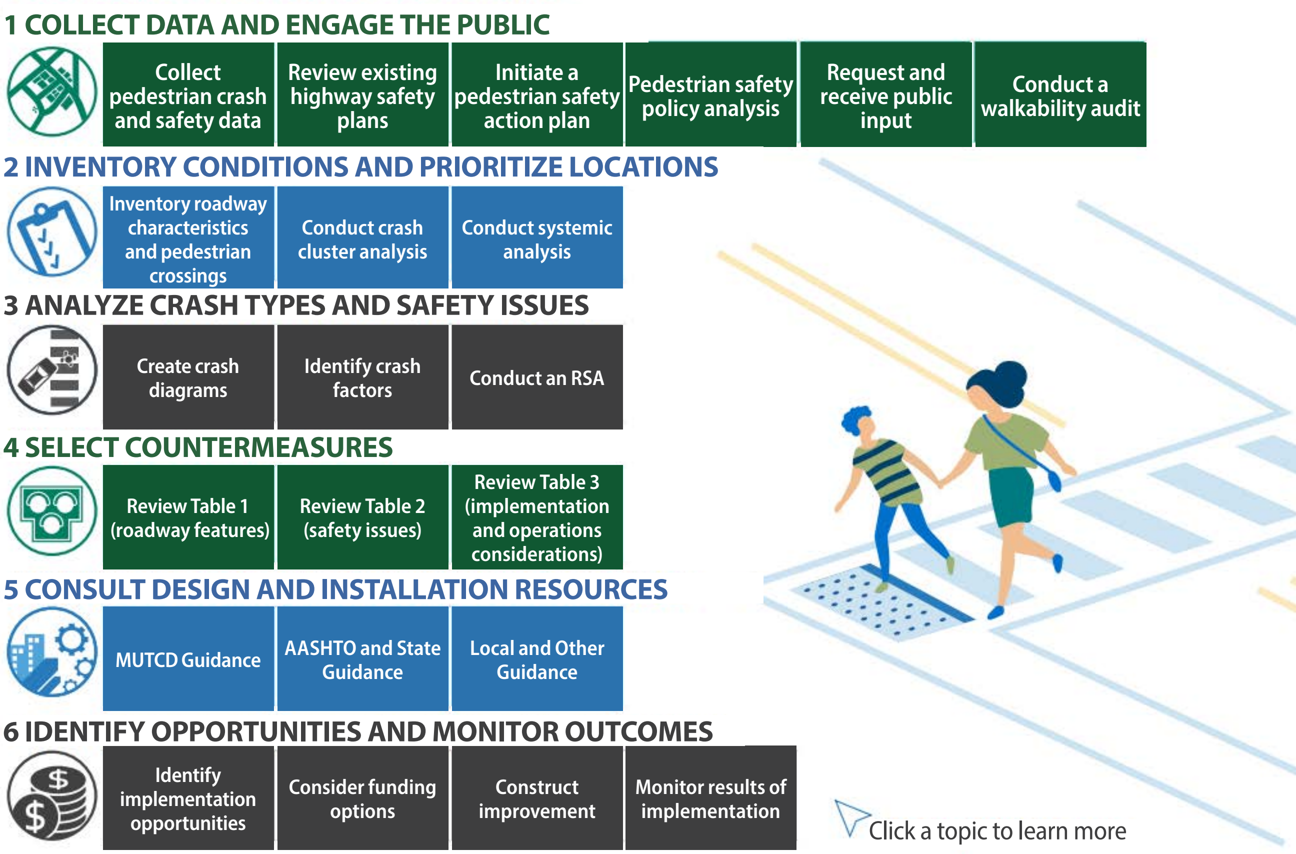
Source: FHWA 2021b.

Figure 13. Graphic. Proven Safety Countermeasure Summary.

The *Proven Safety Countermeasure Selection Tool* indicates that 26 of the 28 countermeasures, including all in the speed management, intersections, pedestrian/bicycles, and crosscutting categories, are applicable to urban areas. This initiative generally supports the Safe System Approach, but application of these countermeasures in the urban core context is not always specifically described. However, many of the other countermeasures are noted as relevant in the urban context as well as more broadly. One mention of the urban core is included within the countermeasure related to Appropriate Speed Limits for All Road Users; specifically, "the use of 20 mph speed zones or speed limits in urban core areas where vulnerable users share the road environment with motorists may result in further safety benefits" (Federal Highway Administration 2021).

FHWA SAFE TRANSPORTATION FOR EVERY PEDESTRIAN (STEP)

The FHWA STEP program provides assistance on how to conduct systemic safety analyses and apply relevant countermeasures for increased pedestrian safety (Federal Highway Administration 2022a). Many of these countermeasures apply in an urban core, where large numbers of pedestrians are often present, and thus their safety needs to be prioritized. The STEP program was included in FHWA's Every Day Counts (EDC) program from 2017–2020 as a proven but underutilized innovation. The STEP program selection process applies the Safe System Approach via the steps outlined in Figure 14.



Source: FHWA. n.d.(e)

Figure 14. Graphic. STEP Selection Process.

FHWA COMPLETE STREETS INITIATIVE

FHWA's Complete Streets initiative is an implementation strategy of the Safe System Approach focused on Safe Roads and Safe Speeds, which seeks to improve safety and access for all road users. In March 2022, FHWA released a report to Congress entitled *Moving to a Complete Streets Design Model: A Report to Congress on Opportunities and Challenges* (Federal Highway Administration 2022e). This report details FHWA's commitment to advance widespread implementation of the Complete Streets design model to help improve safety and accessibility for all users and identifies five overarching opportunity areas that will inform FHWA as it moves ahead with its efforts to increase the proportion of federally funded transportation projects that are routinely planned, designed, built, and operated as Complete Streets (Federal Highway Administration 2022e). More information on the FHWA Complete Streets is available at https://highways.dot.gov/complete-streets.

AASHTO POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS, 7TH EDITION

The AASHTO Policy on *Geometric Design of Highways and Streets, 7th Edition* is a nonregulatory manual containing current design research and practices for highway and street geometric design (American Association of State Highway and Transportation Officials 2018).

It provides recommendations to engineers and designers who strive to develop design solutions that meet the needs of highway and street users on a project-by-project basis. It describes how geometric design elements affect multiple transportation modes and recognizes the relationship between geometric design features and traffic operations.

The *Policy on Geometric Design of Highways and Streets, 7th Edition* acknowledges that geometric design traditionally considered only two contexts—rural and urban—with supplemental recommendations provided for specific locations. This current edition contains a broader set of contexts for geometric design using five contexts: two for rural areas and three for urban areas, including the urban core.

Safety is generally used as a design criterion for decision makers to consider or as a rationale for specific design elements in the manual. In the manual, safety is mentioned with respect to speed, access control (chapter 2), turning radius (chapter 3), cross sectional elements (chapter 4), local and collector roads and street design (chapter 5 and 6), intersection design (chapter 9), and grade separation (chapter 10).

The manual acknowledges that trade-offs often need to be made when balancing the needs of all users, but it does not contain explicit safety performance relationships that identify the safety impact of these trade-offs.

HIGHWAY SAFETY MANUAL

The *Highway Safety Manual* (HSM) is an AASHTO publication and serves as a nonregulatory resource regarding incorporating quantitative safety analysis in the highway transportation project planning and development processes (American Association of State Highway and Transportation Officials 2010). The HSM represented a shift from nominal safety, which assumes that the application of a design standard provides safety, to substantive safety, which relies on scientific findings for determining safety performance that takes into consideration facility type, traffic volumes, and crash history. Although not focused on the Safe System Approach, the HSM introduced a predictive safety methodology that allows practitioners to assess the safety performance of each roadway segment and intersection based on specific characteristics, such as lane width, presence of turn lanes, intersection skewness, intersection traffic control, etc. With the predictive methodology in the HSM, it is possible to compare different countermeasures and select the alternatives with the best estimated safety performance, which is in line with the Safe Roads element of the Safe System Approach. The predictive methodology in the HSM can provide practitioners with estimated future safety performance, which helps inform the design of safer facilities before crashes occur, in line with the Safe System approach that safety is proactive. In addition to road geometry and traffic control, the predictive methodology supports the use of Crash Modification Factors (CMFs) that can be used by practitioners to compare scenarios, such as the safety effects of reducing the speed limit on a roadway segment, which can bring Safe Speeds into roadway design decisions.

The HSM is divided into four sections: Part A – Introduction, Human Factors and Fundamentals of Safety, Part B - Roadway Safety Management Process, Part C - Predictive Methods, and Part D - Crash Modification Factors. The HSM provides safety knowledge and tools to facilitate improved decision making based on quantitative information to improve safety performance. The HSM presents tools and methodologies for consideration of safety across the range of highway activities: planning, programming, project development, construction, operations, and maintenance. The HSM is written for practitioners at all agency levels and across the transportation system, including in the urban core. In chapter 17, on Road Networks, it presents CMFs applicable to planning, design, operations, education, and enforcement-related decisions that are applied holistically to a road network. However, human factors addressed in chapter 2 are focused on driving tasks and do not reference walking or biking factors.

Safety Performance Functions (SPFs) are provided for urban arterials. Geometric design and traffic control features used to determine whether site-specific conditions vary from the base condition in the SPF include on-street parking, driveways, bus stops, right-turn-on-red restrictions, and pedestrian volumes, all of which are relevant to the urban core context. Several roadway segment treatments for pedestrians and bicyclists are noted to have the potential to change user behavior. Geometric design and traffic control features used to determine whether the site-specific conditions vary from the base condition in the SPF include speed category based on actual operating speed or posted speed limit.

In its current form, the HSM has limited direct application to the specific urban core context given the definition used for urban and the types of treatments that are applicable. However, a new edition of the HSM is currently under development, which is anticipated to improve its direct applicability to the urban core context.

NONREGULATORY GUIDES FROM THE NATIONAL ASSOCIATION OF CITY TRANSPORTATION OFFICIALS (NACTO)

NACTO has also developed specific design information focused on urban areas in the following nonregulatory guides that can be viewed through the lens of the Safe System Approach:

- *Urban Street Design Guide:* This manual focuses on the design of city streets and public spaces and emphasizes city street design as a unique practice with its own set of design goals, parameters, and tools (National Association of City Transportation Officials 2013).
- *Urban Bikeway Design Guide:* This manual seeks to provide cities with state-of-the-practice solutions that can help create complete streets that are safe and enjoyable for bicyclists (National Association of City Transportation Officials 2014).
- *Don't Give Up at the Intersection:* This report expands on the Urban Bikeway Design Guide by adding detailed information on intersection design treatments that reduce vehicle-bike and vehicle-pedestrian conflicts. It covers protected bike intersections, dedicated bike intersections, and minor street crossings as well as signalization strategies to reduce conflicts and increase comfort and safety (National Association of City Transportation Officials 2019).
- *City Limits: Setting Safe Speeds in Urban Areas:* This manual gives practitioners a detailed, context-sensitive method to set safe speed limits on urban streets (National Association of City Transportation Officials 2020).

PIARC ROAD SAFETY MANUAL

According to PIARC, the new Road Safety Manual (RSM) will focus on aiding countries, regardless of their stage of infrastructure development, in fulfilling their road safety objectives. It will do this in part by leveraging and promoting the Safe System approach to managing safety, but these efforts will also draw upon assistance from PIARC as well as from other international organizations. The goal of the 2019 update is to add new information, best practices, and new case studies (PIARC (World Road Association) 2019). While the RSM is not developed solely for the urban core, it could form the basis for how to prioritize safety and implement the Safe System Approach in the United States within the urban core and beyond.

Overall, this manual provides a framework, process, and holistic lens that future design work can follow. The following list, excerpted from RSM Section 4.6, provide important perspectives on Safe System Principles (PIARC (Word Road Association 2019):

- The combination of infrastructure safety features, vehicle safety features, and travel speed(s) of crash-involved vehicles determines the impact forces that humans are subjected to in any crash. These interactions are to be managed to avoid fatal or serious injury outcomes.
- Safety levels are to be the key determinant of sustainable mobility levels. Travel speeds require management to target levels below those known speed thresholds that deliver fatal or serious injury crash impact energies (based on the level of vehicle safety and mix) and the nature of protective infrastructure characteristics.
- A system-wide intervention strategy addressing all crash-phases and all Safe System elements is to be adopted, which addresses the safety of all road users.

Individual design treatments are not addressed within this manual; rather, references are provided so designers can get more information and applications relative to country-specific guidance (PIARC (World Road Association) 2019).

The Safe System Approach Framework in the Urban Core

The complexity of an urban core, which includes a high level of activity and a variety of road users, results in safety concerns. Higher volumes, higher speeds, multilane roads, and high potential for conflicts can increase the risk for fatalities and severe injuries in an urban core, especially for vulnerable road users. The application of the Safe System Approach to address these concerns should focus on the following key framework strategies (Road to Zero Coalition n.d.):

- Separation of road users in space and time
- Reduction of crash kinetic energy
- Increased attentiveness and awareness

SEPARATION OF USERS IN SPACE AND TIME

One of the main concerns in the urban core is the vulnerability of non-motorized users, which often requires greater separation between pedestrians, bicyclists, and automobiles. In denser urban areas, pedestrian activity may also cross contexts or land-use boundaries, necessitating the accommodation of pedestrian traffic through a context area to another major area of activity. Therefore, separating road users in space and time in the urban core achieves the following purposes.

- **Separating users in space:** Consists of separating the physical space to provide travelers with a dedicated part of the right-of-way. Typically, travelers moving at different speeds or different directions are separated in space to minimize conflicts with other road users.
- **Separating users in time:** Assumes that users will need to occupy the same physical space on the roadway but creates a safer environment by separating the users in time by way of traffic control devices to minimize vehicle conflicts with vulnerable road users.

The resources described below, which include recommendations for levels of separation in time and space on roadways in an urban core, focus on vulnerable road users. Higher levels of separation between vehicular traffic and vulnerable road users are preferred when possible.

SEPARATION IN SPACE

Bicyclist Separation

Bicycle selection is a context-sensitive decision that involves policy, planning, and project purpose. The desired bikeway type and the amount of separation necessary for a bicycle facility is dependent mostly on the following: the speed of motorized traffic on the adjacent roadway, the amount of motorized traffic on the adjacent roadway, and the amount of bicycle traffic on the facility. In an urban core, higher-speed urban arterials that also serve as a regional bicycle connection typically have heavier volumes of bicycle traffic. In this case, bicyclists would benefit from a separated facility that would reduce the number of conflicts between vehicles and bicycles. Conversely, at a low-speed neighborhood street serving mostly local drivers and bicyclists, bicycles and vehicles may share the same space because of the lower probability of conflict and lower speed differences between the two modes.

Bicycle separation levels are as follows:

- **High separation:** Physical separation from traffic in the form of physical barrier or lateral buffer. Examples include buffered bike lane/cycle tracks and multi-use paths.
- **Medium separation:** Dedicated space adjacent to motorized traffic, such as bike lanes.
- **Low/No separation:** Joint-use facilities for motorized and non-motorized traffic, such as bicycle sharrows.

Resources that can inform practitioners of how to separate bicyclists in space include the following:

- *Bicycle Safety Guide and Countermeasure Selection System:* Presents practitioners with guidelines for selection of different levels of bicyclist separation in space (Federal Highway Administration 2014). For each countermeasure, the purpose, considerations, estimated cost, and safety effects are included.
- *Bikeway Selection Guide:* Provides information on bicyclist separation in space based on traffic volumes and vehicular speeds (Federal Highway Administration 2019).
- National Cooperative Highway Research Program (NCHRP) Report 855: An Expanded Functional Classification System for Highways and Streets: Identifies the recommended level of bicyclist separation in space based on roadway classification and bicycle facility class (Stamatiadis et al. 2018).

Pedestrian Separation

The width necessary for a pedestrian facility along the roadway (sidewalk) typically depends on the speed of motorized traffic on the adjacent roadway and required separation, the amount of motorized traffic on the adjacent roadway, and the amount of pedestrian traffic adjacent to the roadway. In all contexts, FHWA recommends a minimum sidewalk width of five feet for two adult pedestrians to comfortably walk side-by-side. In an urban core, where larger volumes of pedestrians often occur, FHWA recommends wider sidewalks to accommodate two-way pedestrian traffic, congregating groups of pedestrians, and street furniture. The resources listed below can inform practitioners of pedestrian separation in space in an urban core:

- *Roadside Design Guide:* Presents a synthesis of current information and operating practices related to roadside safety, including design features for urban areas (AASHTO, 2011).
- *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations:* Presents guidance for selecting uncontrolled crossing location countermeasures based on roadway configuration, posted speed limit, and traffic volumes (Federal Highway Administration 2018).
- NCHRP Report 855: *An Expanded Functional Classification System for Highways and Streets:* Identifies the level of pedestrian separation in space based on roadway classification and pedestrian traffic level (Stamatiadis et al. 2018).
- *Pedestrian Safety Guide and Countermeasure Selection System:* Provides practical guidance for separating pedestrians in space at numerous transportation facilities such as crossing locations, intersections, transit stops, railroad crossings, and along the roadway (Federal Highway Administration 2013b).

Transit User Separation

Transit routes are typically fixed and well-defined by the local transit agency to meet the demands of the transit ridership. It is important to coordinate with local agencies to establish the transit overlays and ensure safe and accessible access to transit stops and to accommodate the needs of transit riders. Resources that can inform practitioners of overall considerations for transit user separation in space include the following:

- *Improving Safety for Pedestrians and Bicyclists Accessing Transit:* Many transit riders start their trip by walking, rolling, or bicycling (Federal Highway Administration and Federal Transit Administration 2022). This manual was developed for use of transit agencies, State and local roadway owners, and regional organizations involved with planning and designing transit stops and the pedestrian and bicycle facilities that provide access to transit.
- *Manual on Pedestrian and Bicycle Connections to Transit:* Provides a compendium of noteworthy practices to improve pedestrian and bicycle safety and access to transit, including information on evaluating, planning for, and implementing improvements to pedestrian and bicycle access to transit (Federal Transit Administration 2017).
- *Urban Street Design Guide:* Provides considerations on sidewalks to access transit stops, street crossing locations, dedicated waiting areas, and accessible boarding and alighting areas (National Association of City Transportation Officials 2013).

SEPARATION IN TIME

Bicyclist Separation

In the context of the urban core, a few methods for separating bicyclists in time are the following:

- **Bicycle signal face:** At intersections where bicycle movements need to be separated in time from a conflicting vehicular movement, such as locations with a high volume of turning vehicles, bicycle signal faces can allow for a separate bicycle phase or movement. Bicycle signal faces are currently allowed through the *Manual on Uniform Traffic Control Devices* (MUTCD) Interim Approval for Optional Use of a Bicycle Signal Face (IA-16), which requires jurisdictions to receive approval from FHWA prior to using this treatment (Federal Highway Administration 2013a).
- **Leading Bicycle Interval (LBI):** An LBI provides bicyclists with several seconds of green time before the concurrent vehicular movement receives a green indication. This early green interval gives bicyclists a head start at establishing themselves in intersections.

Resources that can inform practitioners of how to separate bicyclists in space include the following:

- *Bicycle Safety Guide and Countermeasure Selection System:* Presents practical guidance on separating bicycle movements in time based on intersection and midblock crossing characteristics (Federal Highway Administration 2014).

Pedestrian Separation

A few examples of how pedestrian separation in time can be achieved in the urban core include the following:

- **Exclusive pedestrian phasing:** Exclusive pedestrian phasing is a pedestrian phase that is active only when all conflicting vehicle movements are stopped across an approach to an intersection. It is important to carefully consider accessibility to all pedestrians. Accessible Pedestrian Signals (APS), for example, can be integrated to communicate information in non-visual formats.
- **Split phasing:** In split phasing, the vehicular green phase is split into two parts: (1) pedestrians receive protected walk time while vehicles traveling in parallel are given a green signal to go straight but not turn, and (2) the pedestrian DON'T WALK is activated when vehicles are permitted to turn. Considering accessibility for all pedestrians is important when implementing split phasing.
- **Leading Pedestrian Interval (LPI):** As with an LBI, an LPI gives pedestrians an advance walk signal before motorists receive a green signal, giving the pedestrian several seconds to start walking in the crosswalk before a concurrent signal is provided to vehicles. LPIs are one of FHWA's Proven Safety Countermeasures (Federal Highway Administration 2021); transportation agencies should refer to guidance in the MUTCD on LPI timing and ensure that pedestrian signals are accessible for all road users.
- **Left turn phasing:** The use of concurrent, protected/permissive, or protected left turn phasing provides different levels of conflict reduction with parallel pedestrian movements.

The resources listed below can inform practitioners of pedestrian separation in time in an urban core:

- *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations:* Presents guidance for selecting uncontrolled crossing location countermeasures based on roadway configuration, posted speed limit, and traffic volumes (Federal Highway Administration 2018).
- *Pedestrian Safety Guide and Countermeasure Selection System:* Provides practical guidance on pedestrian separation in time based on intersection and midblock crossing characteristics (Federal Highway Administration 2013b).

REDUCTION OF CRASH KINETIC ENERGY

The kinetic energy of a moving object is proportional to its mass and to the square of its velocity. During a crash, a fatal or serious injury can occur when kinetic energy exceeds the human body's threshold for tolerating crash forces. In an urban core, especially due to the presence of vulnerable road users, it is important to reduce the kinetic energy in the event of a crash, which can be primarily achieved through speed reduction (Kumfer et al. 2019).

To address speed reduction in an urban core, the following elements should be considered:

- Design speed and target speed
- Speed limit reduction
- Speed reduction through engineering
- Speed reduction through education and high-visibility enforcement and/or speed safety cameras

Design Speed and Target Speed

Design speed has been considered a primary factor in determining highway design criteria. According to the AASHTO *Policy on Geometric Design of Highways and Streets, 7th Edition,* design speed is a selected speed used to determine the various geometric design features of the roadway. Traditionally, design speed has mostly been based on the needs of vehicular traffic (American Association of State Highway and Transportation Officials 2018).

In project design, transportation professionals can consider a roadway's target speed, which is defined as the highest speed at which vehicles should operate on a thoroughfare in a specific context, consistent with the level of multi-modal activity generated by adjacent land uses, to provide both mobility for motor vehicles and a supportive environment for pedestrians, bicyclists, and public transit users (Federal Highway Administration 2020). Practitioners should consider whether a lower target speed is appropriate for thoroughfares in walkable, mixed-use urban areas.

Speed Limit Reduction

One approach that agencies have taken in recent years to encourage lower speeds is to statutorily reduce speed limits on arterials or local residential streets in urban areas. Recently, city and State transportation agencies committed to Vision Zero, Toward Zero Deaths, and the Safe System Approach have been reducing speed limits and exploring new methodologies to determine speed limits to increase safety. There are several studies that discuss the potential impacts of speed limit reduction on safety (Milton et al. 2021; Anderson, Monsere, and Kothuri, 2020; Karnadacharuk and McTiernan 2019; Jurewics and Hall 2009).

Speed Limit Setting

Section 2B.13 of the MUTCD specifies that speed limits (other than statutory speed limits) must be established on the basis of an engineering study, which must include an analysis of the current speed distribution of free-flowing vehicles and may include consideration of a number of other factors related to road characteristics, road context, road users, and crash experience (Federal Highway Administration 2009). Consideration of these additional factors in the urban core may result in a decision to set the speed limit lower than the speed of free-flowing vehicles.

Speed Reduction Through Engineering

Reducing speed limits alone often will not achieve a desired operating target speed. Designs and retrofits that alter the configuration of the roadway or driver perception can be implemented to create friction and reduce vehicular speeds. A few strategies that can be considered in the urban core include the following:

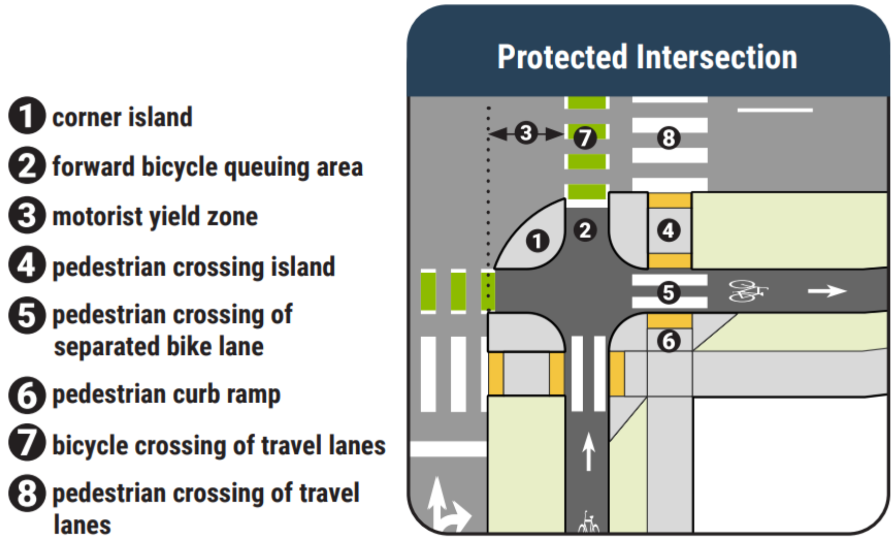
- Traffic calming (Federal Highway Administration 2017)
- Traffic signal timing (Furth et al. 2018)

In the urban core, the needs of non-motorized road users should be considered. Reducing vehicular turning speeds is important for pedestrian and bicyclist safety. Some design measures are listed below:

- Minimizing the size of a corner radius creates compact intersections with safe turning speeds and shorter crossing distances. In urban settings, smaller corner radii are preferred, and many cities use corner radii as small as 2 feet (National Association of City Transportation Officials 2013).

- “Protected intersections” can reduce the likelihood of high-speed vehicle turns, improve sightlines, and reduce the distance and time during which bicyclists are exposed to conflicts (National Association of City Transportation Officials 2019).

Figure 15 shows an example of a protected intersection diagram.



Source: NACTO 2019.

Figure 15. Graphic. Protected intersection diagram.

Speed Reduction Through Education and Enforcement

Education and targeted enforcement can also be part of the strategy to discourage speeding and achieve target speeds in the urban core (Malin and Luoma 2020). With respect to enforcement measures, such as high-visibility enforcement and speed safety cameras, it is important to ensure that equity is considered when implementing these measures. Speed safety cameras are included in FHWA’s *Proven Safety Countermeasure Selection Tool.*

INCREASED ATTENTIVENESS AND AWARENESS

The presence of several road user types in an urban core and the high level of interactions between them requires increased road user attentiveness and awareness. A typical marked crosswalk or a pedestrian warning sign may not be sufficient for drivers to anticipate the presence of pedestrians and yield to them. Increasing visibility through street lighting or daylighting intersections and adding conspicuity enhancements to traffic control devices, for example, may be important in an urban core. Resources that can educate practitioners on increasing attentiveness and awareness in an urban core include the following:

- *MUTCD:* The MUTCD contains the national standards governing all traffic control devices. Chapter 2A of the MUTCD contains the provisions for signs, including information on how to enhance sign conspicuity based upon engineering judgment (Federal Highway Administration 2009).
- *Proven Safety Countermeasures:* This publication provides practical guidance to help practitioners understand the safety effectiveness of traffic control device enhancements applicable to an urban core, such as signal backplates with reflective borders, crosswalk visibility enhancements, rectangular rapid flashing beacons, and street lighting (Federal Highway Administration 2021).

Urban Core Countermeasures

The following countermeasures can be useful in applying the Safe System Approach framework in an urban core. For more information on countermeasures and their safety effectiveness, visit FHWA's Proven Safety Countermeasures, FHWA's *Bicycle Safety Guide and Countermeasure Selection System*, FHWA's *Pedestrian Safety Guide and Countermeasure Selection System*, and FHWA *Crash Modification Factor Clearinghouse*.

Speed Management

- Advisory Speed Plaques
- Reduced Speed Limit Ahead Signs
- Speed Feedback Signs
- Speed Safety Cameras
- Appropriate Speed Limits for All Road Users

Signs and Sign Enhancements

- Rectangular Rapid Flashing Beacons

Signals

- Leading Bicycle/Pedestrian Intervals
- Exclusive Pedestrian Phasing
- Split Phasing
- Reduced Left-Turn Conflict Intersections
- Green Wave Signal Timing
- Yellow Change Intervals
- Bicycle Signals
- Pedestrian Hybrid Beacons
- Backplates with Retroreflective Borders

Markings

- High-Visibility Crosswalks
- Wider Edge Lines

Vertical Separation

- Separated Bicycle Lanes
- Bollards, Planters, and Delineators

Vertical Deflection

- Raised Intersections
- Raised Crosswalks
- Speed Tables, Humps, and Bumps
- Speed Cushions

Road Geometry

- Road Diets
- Medians and Pedestrian Refuge Islands
- Protected Intersections
- Roundabouts
- Curb Extensions
- Reduced Curb Radii
- Left-Turn Hardening

Crosscutting

- Lighting
- Local Road Safety Plans

Applying the Safe System Approach in the Urban Core

This section outlines key steps for applying the principles, elements, and framework of the Safe System Approach in policy, program, and project decision-making processes for transportation professionals making planning and engineering decisions and elected officials making policy decisions. These checklists are based on existing information in place in the United States, including existing informational reports from FHWA. These checklists may be applicable to all or portions of a policy or project, and applying as many components as possible of these checklists that are applicable to the given context should be considered. These checklists outline a path for how to apply the Safe System Approach in the urban core.

These checklists describe a process for both quantitatively and qualitatively prioritizing safety in transportation decisions; however, they are not meant to be standalone tools. Practitioners should reference the original source cited for full context and safety considerations in using these checklists. Context sensitive design and solutions, design flexibility, and engineering judgment are all key when using these checklists, and safety should remain a top priority. Practitioners are encouraged to ensure that as many elements are considered as possible in their decision-making process and through the lens of what is going to create the least crash-severity risk for all road users present.

The first checklist is intended to serve as a planning tool for practitioners to apply the Safe System Approach at a broader level, while the project checklist is intended for specific projects in the urban core. The checklists later in this chapter provide more specific factors for common safety challenges in the urban core. The recommended order to use the checklists included in this chapter is shown below:

1. **Safe System Approach in the Urban Core Safety Planning Checklist:** This checklist is a starting point, and it can be used to inform practitioners at a broader level. Steps 1 through 4 focus on agency decision making, big picture safety concerns, development of safety plans, and collaborations for safety decisions. When reaching Step 5 of this checklist, practitioners can refer to the "Safe System Approach in the Urban Core Project Checklist" to understand the steps for implementing a project following systemic or site-specific levels.
2. **Safe System Approach in the Urban Core Project Checklist:** After an overview of the system's safety concerns are identified and a safety plan is elaborated, practitioners are ready to use this second checklist to understand the detailed steps for implementing systemic and site-specific projects, from project planning to maintenance. Step 1 of this checklist informs how system safety issues can be prioritized for further investigation into factors contributing to crashes. The "Systemic Safety Analysis Checklist" can be used as a reference for Step 1 of the project checklist. When projects are defined, Step 2 focuses on existing conditions, specific issues, and proposed solutions to improve safety. On Step 2, practitioners can refer to the remaining checklists (Urban Arterials in an Urban Core Checklist, Speed Limit Setting Checklist, Urban Core Intersections Checklist, and Vulnerable Road Users Checklist) to identify safety improvements that can address safety challenges specific to the project.
3. **Systemic Safety Analysis Checklist:** Introduced during Step 2 of the Safe System Approach in the Urban Core Project Checklist, to be used as a reference for systemic projects.

4. **Urban Arterials in an Urban Core Checklist, Speed Limit Setting Checklist, Urban Core Intersections Checklist, and Vulnerable Road Users Checklist:** These checklists are used when the project focus has been defined, and help practitioners identify proposed solutions to specific project concerns. These checklists can be used for both systemic and site-specific projects.

SAFE SYSTEM APPROACH IN THE URBAN CORE SAFETY PLANNING CHECKLIST

The planning checklist is intended to serve as a tool for practitioners to apply the Safe System Approach at a broader policy, program, and project level. The planning checklist below was adapted from the FHWA Safe Transportation for Every Pedestrian (STEP) Studio (Federal Highway Administration n.d.(e)):

1. Apply the Safe System Approach elements, principles, and framework across all agency decision making processes.
   a. Ensure all elements are considered in agency processes
   b. Apply all principles in a way that prioritizes safety for all road users
   c. Consider the Safe System Approach framework in all actions of the agency
2. Identify the problems
   a. Collect data
   b. Engage the public
   c. Inventory conditions and prioritize locations
   d. Analyze crash types and safety issues
   e. Disaggregate data to identify equity issues
   f. Conduct road safety audits
3. Develop safety action plans
   a. Engage the public throughout
   b. Identify a goal year to eliminate traffic fatalities
   c. Incorporate the elements, principles, and framework of the Safe System Approach
   d. Include the core elements of Vision Zero
   e. Conduct safety analysis
   f. Incorporate equity considerations such as demographic and health data
   g. Create goals that can be achieved and are aspirational
   h. Set actions that are clear and measurable
   i. Change processes and system elements toward prioritizing safety
   j. Include performance measures that help track progress toward zero traffic deaths (Vision Zero Network 2018)
4. Collaborate on safety decisions
   a. Engage the public, reduce barriers to participation, and expand opportunities for engagement
   b. Include the needs of underserved communities
   c. Engage elected and appointed officials

   d. Engage key stakeholder groups
   e. Integrate safety into all agency departments
   f. Work closely with partner agencies
   g. Review agency policies for prioritizing safety
   h. Ensure safety is a priority in budgets

5. Implement strategies and solutions (refer to the "Safe System Approach in the Urban Core Project Checklist")
   a. System planning
   b. Project planning and preliminary engineering
   c. Countermeasure selection
   d. Consult design resources
   e. Design and construction
   f. Maintenance and safety monitoring
6. Identify additional opportunities and monitor outcomes

SAFE SYSTEM APPROACH IN THE URBAN CORE PROJECT CHECKLIST

The following checklist should be applied at a project level in addition to the safety planning checklist outlined previously. The below checklist applies to all projects, either at a systemic level or site-specific level. This checklist outlines key things to keep in mind throughout a transportation project from planning through maintenance.

Step 1: System Planning

a. Determine priority corridors using high injury network mapping to understand existing crash contributing factors and conduct systemic safety analyses through network screening of similar conditions (refer to "Systemic Safety Analysis Checklist").
b. Evaluate social, demographic, and health data to identify underserved communities.
c. Engage the community in the discussion of safety needs and build trust.
d. Determine if any policy or standards should and can be changed to prioritize safety.
e. Develop, update, or align a proactive safety plan across the agency with specific safety performance measures, such as a Vision Zero Action Plan, Local Road Safety Plan, or Strategic Highway Safety Plan.

Step 2: Project Planning and Preliminary Engineering

a. Observe existing conditions including safety risks, accessibility barriers for individuals with disabilities, and how all road users are operating.
b. Establish modal priorities.
c. Identify land use generators.
d. Determine how safety and accessibility could be prioritized.
e. Measure crash risk and understand crash causation.
f. Conduct a risk assessment.
g. Identify ways to reduce conflicts.
h. Engage the community in the design process.
i. Ensure that key Safe System Approach elements in an urban core are incorporated (refer to the Key

Safe System Approach Elements in an Urban Core section).

i. Separate users in space and/or time in a way that will prevent a crash from being fatal.
ii. Increase attentiveness and awareness of all road users.
iii. Reduce impact forces.
iv. Reduce speeds.

j. Apply the Urban Core Challenge Checklists as needed (refer to Urban Arterials in an Urban Core Checklist, Speed Limit Setting Checklist, Urban Core Intersections Checklist, and Vulnerable Road Users Checklist).

k. Develop concept design through the lens of the Safe System Approach while ensuring that pedestrian facilities are accessible to and usable by individuals with disabilities.

l. Determine countermeasures that will eliminate fatal and serious injury crashes (refer to Urban Core Countermeasures).

m. Estimate safety effectiveness of implementing countermeasures.

n. If possible, revise any further policies or standards that limit prioritizing safety as the goal.

o. Present project to the community for feedback and ensure it prioritizes safety.

Step 3: Design and Construction

a. Design using key elements as outlined in the Key Safe System Approach Elements in an Urban Core.
b. Ensure projects are constructed using the Safe System Approach.
c. Ensure that elements fundamental to the Safe System Approach and accessibility are not compromised during the design and construction stages.
d. Apply performance-based practical design principles to project investment decisions so that overall system performance is optimized.
e. Report to the community on recent changes and safety benefits.

Step 4: Maintenance and Safety Monitoring

a. Conduct field observations following implementation and make field adjustments.
b. If the project was a temporary or quick build due to a desire to test the safety benefit, monitor and benchmark when permanent improvements will be made.
c. Ensure all traffic control devices are accessible and usable by persons with disabilities.
d. Maintain and replace devices and countermeasures as needed to ensure they continue to provide high safety function.
e. Establish and evaluate performance indicators:
   i. Safety metrics: Fatal and serious injury crashes, safety surrogate variables, perceptions of safety and comfort.
   ii. Mobility metrics: Increases in walking or bicycling, network of pedestrian facilities that are accessible to people with disabilities, curb use that promotes safe mobility for all users, etc.
   iii. Health impact metrics: Hospital data, climate impacts, emergency response and access, access to active transportation opportunities, etc.
   iv. Community perception and feedback metrics: Interviews, surveys, focus groups, walk audits/ assessments, etc.
f. Document effectiveness of safety improvement, including key countermeasure details that worked and how.
g. If fatal and serious injury crashes are still occurring, make field adjustments beginning with Step 2.
h. Determine where and how the application can be applied across the network for safety improvement using systemic safety analysis.

SYSTEMIC SAFETY ANALYSIS

The systemic approach to safety is a data-driven process that involves analytical techniques to identify sites for potential safety improvement and suggests projects for safety investment not typically identified through the traditional site analysis approach (Federal Highway Administration 2013c). Traditional network screening techniques have focused on identifying locations with a history of severe crashes, often known as hot-spot or high injury network mapping. While this is helpful information to know, evidence indicates that severe crashes are actually widely distributed across the local road system, and few individual locations experience a high number or sustained occurrence of severe crashes. As a result, adding a systemic approach to safety management efforts is important to the Safe System Approach. The systemic approach uses historical crash data to identify high-risk roadway features that correlate with recurring severe crashes (Grembek, Pasquet, and Vanoli 2019).

A proactive systemic safety analysis relies on complete and detailed underlying data and should consider safety, mobility, health impacts, and community perception and feedback factors. Integrating equity data into safety analysis is important to fill in gaps in crash reporting and incomplete roadway data. Examples of quantitative and qualitative data that can be used to further understand crash occurrence and severity are listed below:

- Demographic data: Practitioners can disaggregate and examine local crash fatality and serious injury data by social and demographic variables of person and place.
- Health data: Social Determinants of Health, hospital data, and emergency response data can inform data analysis (Centers for Disease Control and Prevention n.d.).
- Community perception and feedback data: Qualitative information can be derived from interviews, surveys, focus groups, and road safety audits (RSA).

For further information on systemic safety analysis, there are several additional references available for practitioners (Waldheim, Wemple, and Fish 2015; National Highway Traffic Safety Administration 2017; Grembek, Pasquet, and Vanoli 2019; Torbic, Hutton, Kolody Silverman, and Harwood 2020).

Systemic Safety Analysis Checklist

To conduct systemic safety analysis in an urban core, follow the methodologies adapted from the FHWA *Systemic Safety Project Selection Tool* as outlined below (Federal Highway Administration 2013c):

1. **Identify Focus Crash Types and Risk Factors**
   - ☐ Task 1: Collect and Analyze Crash and Roadway Data
   - ☐ Task 2: Disaggregate Data by Social and Demographic Variables
   - ☐ Task 3: Select Focus Crash Types
   - ☐ Task 4: Select Focus Facilities
   - ☐ Task 5: Identify and Evaluate Risk Factors
2. **Screen and Prioritize Candidate Locations**
   - ☐ Task 1: Identify Network Elements to Analyze
   - ☐ Task 2: Engage Community Representatives to Understand Safety Needs
   - ☐ Task 3: Collect and Analyze Quantitative and Qualitative Equity Data
   - ☐ Task 4: Conduct Risk Assessment
   - ☐ Task 5: Prioritize Focus Facility Elements
3. **Select Countermeasures**
   - ☐ Task 1: Assemble Comprehensive List of Countermeasures
   - ☐ Task 2: Evaluate and Screen Countermeasures
   - ☐ Task 3: Engage the Community
   - ☐ Task 4: Select Countermeasures for Deployment
4. **Prioritize Projects**
   - ☐ Task 1: Create a Decision Process for Countermeasure Selection, Incorporating Equity Considerations that Eliminate Disparities in Traffic Fatalities and Serious Injuries
   - ☐ Task 2: Develop Safety Projects
   - ☐ Task 3: Prioritize Safety Project Implementation (Preston, Storm, Bennett, and Wemple 2013)
5. **Identify Funding for Systemic Program and Implement**
6. **Perform Systemic Program Evaluation:** Monitor Outcomes and Continuously Improve Outcomes with Communities

There are tools available to assist practitioners in conducting systemic safety analysis. One example is the United States Road Assessment Program (usRAP), a data-driven planning tool for analyzing the safety of a roadway and recommending solutions for addressing safety concerns. usRAP uses video data and predictive risk models to proactively identify potential safety concerns. The tool also assigns star ratings to each road segment on the road network, which can help inform road investment decisions (Roadway Safety Foundation n.d.).

Applying the Safe System Approach to Specific Urban Core Challenges

FHWA has identified critical safety challenges for all road users in an urban core. The following sections provide background, guidance, and a checklist for each challenge area. The checklists included in this section can be used by practitioners as reminders of how existing research and tools are used to ensure the Safe System Approach is applied in an urban core. The urban core safety challenge areas are the following:

- Urban Arterials in an Urban Core
- Speed Management
- Urban Core Intersections
- Vulnerable Road Users

Urban Arterials in an Urban Core

Urban arterials are major and minor thoroughfares that carry higher traffic volumes, generally with higher speed limits, and generally use a design that features multiple wide travel lanes and fewer crossing opportunities for non-motorized users. Most intersections on urban arterials are signalized. Urban arterials were the location of 29 percent of fatal crashes in the United States and 49 percent of fatal crashes that involved people walking and riding bicycles (National Association of City Transportation Officials 2020).

To overcome these safety concerns in an urban core, new development can limit the number of urban arterials and ensure they are designed for safer conditions and preference toward pedestrians and cyclists, while existing urban arterials can be reoriented toward the more efficient movement of mass transport, freight, pedestrians, and bicycles (Welle et al. 2015). It is also important to include context-sensitive roadway design elements rather than focusing solely on the functional classification of a roadway. Important strategies for implementing the Safe System Approach in urban arterials in an urban core include modal considerations and accommodation for drivers, bicyclists, pedestrians, and overlays (transit and freight).

There are a few resources where practitioners can find information in applying the Safe System Approach in urban arterials in an urban core (Turner et al. 2017; Harwood et al. 2008; Federal Highway Administration 2022). A context overlay was added in AASHTO's *Policy on Geometric Design of Highways and Streets, 7th Edition*, based on *NCHRP Report 855: An Expanded Functional Classification System for Highways and Streets* (Stamatiadis et al. 2018), which allows planners and engineers the flexibility to select a roadway design that can achieve its safety and mobility goals based on an expanded functional classification matrix. The framework in NCHRP Report 855 is not specific to the Safe System Approach, but provides examples on how to include context, road functions, and user needs to facilitate urban arterial roadway design in an urban core.

Urban Arterials in an Urban Core Safe System Approach Checklist

Drawn from the methodologies of *NCHRP Report 855: An Expanded Functional Classification System for Highways and Streets* (Stamatiadis et al. 2018):

- ☐ **Review transportation agency policy and planning to understand project vision**
- ☐ **Review available data**
- ☐ **Consider right-of-way and other constraints**
- ☐ **Identify context of the study area**
- ☐ **Identify transportation networks**
  - ○ Automobile, bicycle, and pedestrian networks
  - ○ Overlays (transit, freight)
- ☐ **Identify specific modal accommodation needs**
  - ○ Driver accommodation
  - ○ Bicyclist accommodation
  - ○ Pedestrian accommodation
  - ○ Transit rider accommodation as an overlay
  - ○ Freight accommodation as an overlay
  - ○ Access management
- ☐ **Apply the Safe System Approach framework**
  - ○ Identify road user separation in space
  - ○ Identify road user separation in time
  - ○ Identify ways to reduce kinetic energy in the event of a crash
  - ○ Increase attentiveness and awareness for all road users

Speed Management

Higher speeds are connected to safety concerns. According to NHTSA, of the 11,063 speeding-related fatalities in traffic crashes in 2020 with known roadway function class, 5,473 (49 percent) occurred on non-interstate urban roads (National Highway Traffic Safety Administration 2021). Pedestrians, bicyclists, and other road users outside of vehicles are particularly susceptible to the kinetic energy present in crashes at high speeds.

To implement a Safe System Approach for speed management, it is important to balance three elements: defining a target speed, adjusting the speed limit where necessary, and incorporating engineering measures that support the speed limit. In addition, considerations to speed enforcement and education are important to ensure lower vehicular speeds in an urban core. There are a number of available tools that can help in taking these factors into account while setting context sensitive speed limits. These include USLIMITS2 for Road Sections in Developed Areas, *NCHRP Report 966: Posted Speed Limit Setting Procedure and Tool*, and the NACTO City Limits guide (Federal Highway Administration 2020c; Fitzpatrick et al. 2021; National Association of City Transportation Officials 2020).

- *USLIMITS2 for Road Sections in Developed Areas:* USLIMITS2 is a web-based tool designed to help practitioners set reasonable, safe, and consistent speed limits for specific segments of roads (Federal Highway Administration 2020c). For road sections in the urban core, the following input variables are required: Operating speed (speed distribution of free-flowing vehicles), section length, annual average daily traffic, presence/absence of adverse alignment, current statutory speed limit for this type of road, whether it is a one-way street, number of through lanes (in both directions), area type, number of driveways within the section, number of traffic signals within the section, presence/usage of on-street parking, extent of ped/bike activity, and crash statistics.
- *NCHRP Report 966: Posted Speed Limit Setting Procedure and Tool:* This manual provides and explains a speed limit setting procedure (SLS-Procedure) that considers factors beyond the 85th percentile speed, including both driver speed choice and safety associated with the roadway (Fitzpatrick et al. 2021).
- *NACTO City Limits:* NACTO's resource gives practitioners a detailed, context-sensitive method to set safe speed limits on urban streets (National Association of City Transportation Officials 2020). Using the Safe System Approach, City Limits provides a consistent, rational, scalable approach to urban speed limit setting, from citywide strategies to corridor-by-corridor methods based on easy-to-study street characteristics.

Speed Limit Setting and the Safe System Approach Checklist

The checklist below is based largely on the data inputs of the USLIMITS2 for Road Sections in Developed Areas, *NCHRP Report 966: Posted Speed Limit Setting Procedure and Tool,* and NACTO City Limits document, and is meant to assist practitioners in ensuring that relevant performance and context factors are taken into consideration when setting context appropriate speed limits (Fitzpatrick et al. 2021, National Association of City Transportation Officials 2020).

- ☐ **Operating speed/speed distribution of free-flowing vehicles**
- ☐ **Section length**
- ☐ **Annual average daily traffic**
- ☐ **Presence/absence of adverse alignment**
- ☐ **Current statutory speed limit for this type of road**
- ☐ **Whether it is a one-way street**
- ☐ **Number of through lanes (in both directions)**
- ☐ **Area type**
- ☐ **Number of driveways within the section**
- ☐ **Number of traffic signals within the section**
- ☐ **Presence/usage of on-street parking**
- ☐ **Extent of ped/bike activity**
  - ○ **Bicyclist activity in motor vehicle lane, shoulder, or nonseparated bike lane**
  - ○ **Bicyclist activity in separated bike lane**
  - ○ **Sidewalk presence/width, sidewalk buffer,**
    and pedestrian activity
- ☐ **Crash statistics**
  - ○ **Crash rate**
- ☐ **Apply conflict & activity level analysis to the risk matrix**
  - ○ **Conflict density analysis**
  - ○ **Activity level analysis Urban Core Intersections**

Urban Core Intersections

A notable share of crashes in urban areas occur at intersections due to the complexity of movements and a variety of road users, including pedestrians and bicyclists. Severe intersection crashes are linked to high entry speeds and specific crash impact angles, such as right-angle and head-on (Juerwicz, Tofler and Makwasha 2015). To implement a Safe System Approach at intersections in the urban core, planners and designers should focus on the following four key principles: minimize conflict points, remove/simplify road user decisions, minimize impact angles, and minimize entry and impact speeds. Elements to be considered when selecting an intersection design are the applicable context, alignment with Safe System principles, potential for crash reduction, and cost. (Jurewicz, Chau, et al. 2017).

There are a few comprehensive resources that practitioners can use when selecting intersection design elements aligned with the Safe System Approach (Candappa 2015; Juerwicz, Tofler and Makwasha 2015; Jurewicz, Chau, et al. 2017). The FHWA's *A Safe System-Based Framework and Analytical Methodology for Assessing Intersections* presents a framework that practitioners can use to design and implement intersection projects to improve safety (Federal Highway Administration 2021a). This approach integrates principles such as conflict point identification and classification, exposure, kinetic energy transfer, conflict point severity, and intersection movement complexity. FHWA's framework provides a set of Safe System for Intersection (SSI) scores that can be used as one of several metrics in a countermeasure selection process. The SSI scores rely on data that can be collected fairly easily for a given intersection, and includes posted speed limit, traffic volumes, travel lanes, and turning movements, among others. The SSI framework was not specifically designed for urban areas, but provides example applications for signalized intersections in urban, suburban, and rural environments.

In addition to the SSI framework, FHWA's Intersection Control Evaluation (ICE) is a data–driven, performance–based framework to screen intersection alternatives and identify an optimal solution. Further, the Safety Performance for Intersection Control Evaluation (SPICE) can be used as guidance for making safety improvements at intersections (Federal Highway Administration n.d.(b)).

Additionally, the FHWA *Improving Intersections for Pedestrians and Bicyclists Informational Guide* provides guidance and key design features to accommodate pedestrians and bicyclists at intersections, which is particularly applicable in an urban area where intersections often have the most conflicts and safety risk. This report highlights that "[w]hen designed with pedestrians and bicyclists explicitly in mind, all types of intersections can facilitate safe, accessible, convenient, and comfortable walking and bicycling" (Federal Highway Administration 2022c).

Examples of intersection design elements that can minimize conflict points, remove/simplify road user decisions, minimize impact angles, and minimize entry and impact speeds include the following:

- Left turn hardening
- Reduced curb radii
- Protected intersections
- Roundabouts
- Raised crosswalks or tabled intersection
- Signal timing adjustments that separate users in time
- One-way vs 2-way streets (to reduce conflicts)
- Crosswalk visibility enhancements

Urban Core Intersection Safe System Approach Checklist

The checklist below follows the methodologies presented in *A Safe System-Based Framework and Analytical Methodology for Assessing Intersections* and provides practitioners information on how to design urban core intersections (Federal Highway Administration 2021a):

- [ ] Follow Stage 1 Intersection Control Evaluation (ICE)
- [ ] Calculate Conflict Point Identification and Classification
- [ ] Calculate Crash Frequency and Exposure Rate
- [ ] Calculate Conflict Point Severity
- [ ] Calculate Movement Complexity
- [ ] Determine SSI and Measure of Effectiveness Results
- [ ] Look up in Appendix A: SSI Library of Intersection Types and consider all key characteristics and considerations
- [ ] If possible, expand to other conflict types
- [ ] If possible, develop data and models to support intersection speed prediction
- [ ] If possible, link SSI Measures of Effectiveness and scores to Fatal and Serious Injury crash frequencies (Federal Highway Administration, 2021)

Vulnerable Road Users

People walking, biking, and rolling are the road users most likely to be injured or killed in a crash (Welle et al. 2015). Therefore, the Safe System Approach inherently prioritizes pedestrians and bicyclists in its approach to reducing the risk of fatal and serious injuries of road users (Goughnour et al. 2021). Most interactions between pedestrians and bicyclists and motor vehicles are in urban settings. Protection and consideration for vulnerable road users should be a priority in policy, speed reduction, and pedestrian and bicyclist supporting infrastructure.

Resources that can inform practitioners of vulnerable road user concerns with respect to the Safe System Approach and provide information potential countermeasures include the following:

- *Primer on Safe System Approach for Pedestrian and Bicyclists:* Provides transportation agencies a baseline understanding of pedestrian and bicycle concerns with respect to each of the five elements of the Safe System Approach (Goughnour et al. 2021).
- Pedestrian and Bicycle Information Center: *Micromobility*: Includes a set of resources to better understand the impact of micromobility on the transportation network and provides best practices and considerations to regulate shared micromobility (Federal Highway Administration n.d.(c)).
- Pedestrian and Bicycle Information Center: *Equity:* Provides resources and examples to address safety conditions in communities and underserved populations, where pedestrians and bicyclists are overrepresented in fatal and serious injury crashes (Federal Highway Administration n.d.(a)).

- *Cities Safer by Design: Guidance and Examples to Promote Traffic Safety through Urban and Street Design:* Provides an in-depth resource for the Safe System Approach techniques and evidence-based designs to improve safety on urban facilities including street plazas, transit infrastructure, and arterials (Welle et al. 2015).
- *Towards a Safe System for Cycling:* Identifies potential mitigation initiatives based on analyses that show how the system failed for specific urban cycling crash types (Mackie et al. 2017).
- *NCHRP Report 926: Guidance to Improve Bicycle and Pedestrian Safety at Intersections:* Presents practical guidance to help practitioners select and install countermeasures to improve pedestrian and bicycle safety at intersections, making a connection between systemic safety and a Safe System (National Academies of Sciences, Engineering, and Medicine 2020)
- *NCHRP Report 893: Systemic Pedestrian Safety Analysis:* Provides a framework for a systemic pedestrian safety management process through analysis. It walks state DOT and regional and local agency staff through a seven-step process for a performance-based decision making for pedestrian safety (Thomas et al. 2018).
- *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts:* Guides practitioners on how to reduce multimodal conflicts and achieve connected networks, resulting in safe, comfortable, and attractive options for pedestrians and bicyclists (Federal Highway Administration 2016).
- *NCHRP Report 948: Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges:* Outlines how alternative Intersections and Interchanges should accommodate vulnerable road users (National Cooperative Highway Research Program 2021).

Vulnerable Road Users Checklist

There is not a specific checklist to address vulnerable road users in an urban core. However, following the available steps and guidance for pedestrian safety analysis and tailoring to specific conditions can be applicable to all vulnerable road users. This checklist informs practitioners on how to apply design flexibilities and further reduction of crash conflict through context sensitive design, as adapted from NCHRP Report 893: *Systemic Pedestrian Safety Analysis* and *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts* as outlined below:

- ☐ **Step 1: Define Study Scope**
- ☐ **Step 2: Compile Data**
- ☐ **Step 3: Determine Risk Factors**
- ☐ **Step 4: Identify Potential Treatment Sites**
- ☐ **Step 5: Select Potential Countermeasures**
- ☐ **Step 6: Refine and Implement Treatment Plan**
  - ○ Part 1: Apply Design Flexibility
    - △ *Lane Width*
    - △ *Intersection Geometry*
    - △ *Traffic Calming and Design Speed*
    - △ *Transitions to Main Streets*
    - △ *Road Diets and Traffic Analysis*
    - △ *Enhanced Crossing Treatments*
    - △ *Signalized Intersections*
    - △ *Paved Shoulders*
    - △ *Separated Bike Lanes*
    - △ *Bus Stops*
    - △ *Bridge Design*
    - △ *Slow Streets*
  - ○ Part 2: Reduce Conflicts
    - △ *Network Connectivity*
    - △ *School Access*
    - △ *Multimodal Access to Existing Transit Stations*
    - △ *Multimodal Access to New Transit Stations*
    - △ *Transit Conflicts*
    - △ *Freight Interaction*
    - △ *Accessibility*
    - △ *Turning Vehicles*
    - △ *Sidewalks*
    - △ *Separated Bike Lanes at Intersections*
    - △ *Shared Use Paths*
    - △ *Midblock Path Intersections*
- ☐ **Step 7: Evaluate Program and Project Impacts**

(National Academies of Sciences, Engineering, and Medicine, 2018) (Federal Highway Administration, 2016)

Case Studies of Noteworthy Practices

The appendix contains 10 case studies of noteworthy practices that are relevant to implementing the Safe System Approach in the urban core. Eight of these case studies are from States or cities in the United States and two are from international locations in Europe and South America that cover multiple locations each. The purpose of these case studies is to provide practical examples of how some of the key concepts covered in this report have already been implemented and what benefits have been realized.

Conclusions, Use, and Next Steps

This report has provided some initial information that should be useful to transportation professionals as they explore and implement safety strategies and countermeasures in the context of the Safe System Approach in urban core areas. Implementation of the Safe System Approach in the United States remains relatively new and practices in this area will continue to evolve as more experience is accumulated and more places commit to use of the Safe System Approach. Ultimately, sufficient experience will be gained to confidently develop best practices and more specific guidance for transportation professionals. The urban core environment is a key location where use of the Safe System Approach can be effective in reducing and eliminating fatalities and serious injuries, particularly among vulnerable road users, but it is just a starting point. Full adoption and use of the Safe System Approach will require applying it in all contexts.

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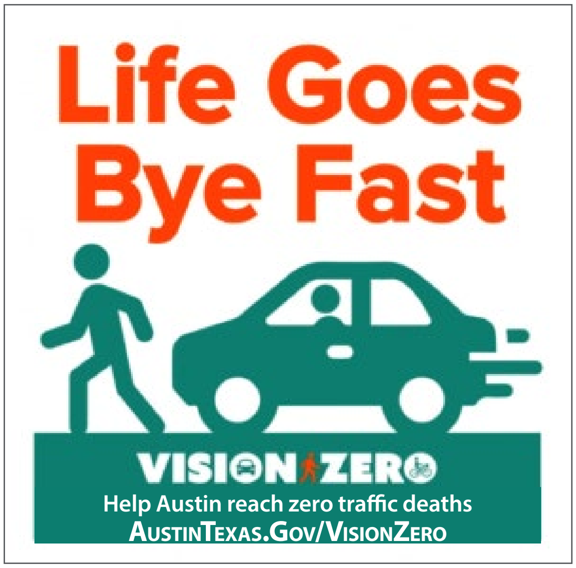
APPENDIX – DETAILED CASE STUDIES OF NOTEWORTHY PRACTICES

Vision Zero Shifts Austin Towards the Safe System Approach –Austin, TX, USA

Key Successes

Although many aspects of the Vision Zero program in Austin, Texas, are early in implementation, initial data is showing positive trends. The Austin city council officially adopted Vision Zero as a city policy goal in 2015. Austin's Vision Zero program is constantly monitoring crash data to continuously make measurements and changes in service to its goal of eliminating serious injuries and fatalities caused by traffic crashes. Some key indicators of the Vision Zero program's impact include the following:

- A 17-percent decrease in serious injury and fatal crashes in 2021 compared to the previous 3-year average on high-injury roadways that received low-cost engineering countermeasures.[1]
- An additional 18-percent reduction in the annual number of pedestrian crashes involving left-turning vehicles at downtown intersections that received leading pedestrian intervals (LPI) in the year following LPI implementation compared with those that did not.[2]
- A 64 percent reduction in the annual number of opposite-direction, left-turn injury crashes at intersections with signal timing adjustments compared with the 3 years before implementation.[3]



Source: City of Austin n.d.

Figure 1. Screenshot. Vision Zero ad in Austin, Texas, USA.

The Safe System Approach Highlights

Death and serious injury are unacceptable: The city of Austin has a GIS crash database and High Injury Network (HIN) to understand where the highest concentration of severe crashes occurs in Austin to help prioritize safety strategies and complement the program's systemic analysis.

Responsibility is shared: The Austin Vision Zero Leadership Council meets approximately every 6 weeks to provide guidance and direction on Vision Zero program priorities and initiatives in the city. The Leadership Council includes cross collaborative departments and partner agencies, including the Texas Department of Transportation (TxDOT), the Travis County Attorney and District Attorney Offices, Austin-Travis County EMS, Austin Fire Department, Austin Police Department, Austin Independent School District, Capital Metropolitan Transportation Authority, city of Austin Housing and Planning Department, Austin Municipal Court, FHWA, and Austin Public Health.[4]

Safety is proactive: The city of Austin is prioritizing safety by applying system-wide changes to road design, such as LPIs and improving street lighting. Austin is also lowering speed limits system-wide and on urban arterials.

Background

After an all-time high number of fatal crashes in 2015, Austin established a goal of zero traffic deaths and serious injuries in 2015 and adopted its first Vision Zero Action Plan in 2016. Within the first few years of the program, the city took a system-wide approach to zero traffic fatalities and severe injuries. The city updated its Vision Zero Action Plan in 2019 as part of its adoption of the *Austin Strategic Mobility Plan* (ASMP), which included an updated set of policies and actions specifically modeled around a Safe Systems Approach.[5] Importantly, the very first goal within the ASMP is to "prioritize the protection of human life over all else in the planning, design, and operation of Austin's transportation network."[6]

Source: City of Austin n.d.

Figure 2. Image. Vision Zero Austin mural.

Thanks to the strong support from the city Manager's Office and city Council, Austin Transportation Department (ATD) created the Transportation Safety Officer position in 2019, and shortly thereafter added three additional full-time positions to support the planning, analysis, and communication needs of the Vision Zero program. After a review of the existing practices relating to resource prioritization within ATD, the city identified a need to improve the program's data analysis capabilities. This led to a revamped Vision Zero program in 2019, working to prioritize the development of new tools to address data challenges and to help support the delivery of new safety initiatives.

Additionally, the Austin Vision Zero Leadership Council includes cross collaborative departments and partner agencies, including TxDOT, the Travis County Attorney and District Attorney Offices, Austin-Travis County EMS, Austin Fire Department, Austin Police Department, Austin Independent School District, Capital Metropolitan Transportation Authority, city of Austin Housing and Planning Department, Austin Municipal Court, FHWA, and Austin Public Health.

Implementation

Austin's commitment to the Safe System Approach, along with robust analysis tools, has helped the city expand the depth and breadth of traffic safety initiatives that are contributing to safety improvements across Austin. In recent years, the city has been able to implement a variety of layered safety initiatives as part of the overall Vision Zero program quickly and effectively, many focused on their high-injury network and urban core.

The Vision Zero Program structure in Austin is proactively addressing high-risk locations to prevent fatal and serious injury crashes as the top priority. This goes beyond the traditional hot-spot approach to roadway safety to also address safety risks where similar roadway conditions exist. The program uses the most recent 5 years of fatal and serious injury crash data to monitor crashes and how safety improvements are working toward a goal of zero traffic deaths.

Austin's Vision Zero Program includes a comprehensive GIS crash database, which allows them to review the data to prioritize safety initiatives and investments at locations with high concentrations of fatal and severe crashes. Crash trends are available via an online viewer, providing increased data transparency and access. The viewer is a tool for engaging with and building the capacity of traffic safety advocates in Austin.[7] The viewer has been critical for ATD engineers evaluating crash patterns to make recommendations for engineering countermeasures. This can be crucial for quick, proactive engineering fixes along the high-injury network and other locations.

Source: City of Austin n.d.(b).

Figure 3. Image. Temporary signage identifying Cameron Road as a high-injury roadway to raise awareness until safety improvements are constructed.

The city of Austin has focused its early Vision Zero improvements on low-cost and high-impact engineering countermeasures that can be deployed at hundreds of locations across the city. Vision Zero staff identified 13 high-injury roadway sections that had a high concentration of both historical crashes and risk factors. The high-injury roadway sections total approximately 31 miles and had 350 serious injuries or fatalities in the 5 years preceding the 2019 update of the Vision Zero plan. These roadway sections received a package of effective, low-cost engineering countermeasures paired with safety signing and targeted enforcement to deter dangerous driving behaviors. Some of the low-cost countermeasures included traffic signal timing, visibility enhancements like retroreflective backplates on traffic signals, and refreshed crosswalk markings.

In 2019, the city implemented a systemic approach to improving pedestrian safety in the urban core. The city implemented leading pedestrian intervals (LPIs) at 110 intersections in downtown Austin using the Safe System Approach.[8] In the year following implementation, data showed an additional 18-percent reduction in annual pedestrian crashes involving left-turning vehicles at downtown intersections that received LPIs versus those that did not.[9] There was also an additional 54-percent reduction in annual pedestrian KAB (combined fatalities, serious injuries, and non-incapacitating injuries) crashes involving left-turning vehicles at these locations. The city is using the experience from the downtown LPIs to inform broader deployment of LPIs across Austin, with a focus on locations where there is a high risk of crashes and high pedestrian volumes, rather than only relying on crash history at each location. Additionally, approximately half of the downtown traffic signals with LPIs have audible pedestrian signals (APS) that also provide accessible signal improvements. Over the next year, the city is using 2020 Bond funds to install APS at all downtown signalized crossings and at many other signalized crossings across the city.

Austin also focused on lower cost signal timing improvements to address intersection crashes. Using both systemic safety and Safe System Approaches, staff reviewed data to understand the time-of-day and day-of-week periods where crashes occurred most frequently and the types of turning movements that led to crashes at intersections. city staff used those findings to make the appropriate safety improvements through signal timing based on the intersection context. These improvements included adding protected-only phasing, installing flashing yellow arrows, and installing more prominent signage or signal heads. Early data shows a 64-percent reduction in the annual number of opposite-direction, left-turn crashes resulting in injuries at intersections where signalization strategies have been implemented, which means approximately 18 fewer people were injured or killed per year at these locations.[10] From this early implementation, city staff are working on updating signal standards to incorporate the Safe System Approach into signalized intersection decision-making processes.

Source: City of Austin n.d.

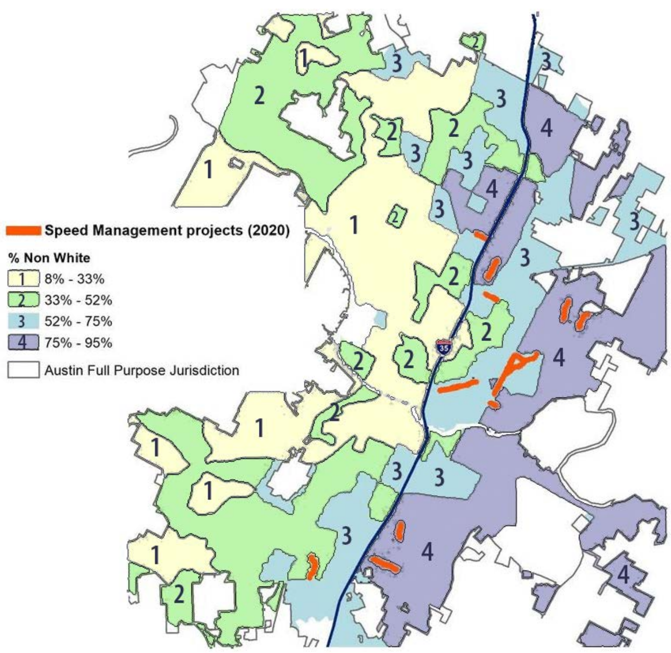
Figure 4. Image. Separated bike lane to sidewalk transition that separates users in space in Austin.

The city further incorporates the Safe System Approach through Austin Transportation's Speed Management Program and numerous other systemic approaches to safety. Between 2013–2017, speeding was a contributing factor in at least 24 percent of the fatal crashes in Austin.(11) Notably, Austin has lowered speed limits citywide and deployed more traffic calming, which includes reduction of speed limits to 35 mph or less on most urban core arterials. Crashes along curves in Austin involving one motor vehicle are a common fatal and serious injury crash type and the city is making safety improvements along curves at more than 40 locations. The city is installing chevrons, warning signs, flashing beacons, LED devices, raised pavement markings, striping, rumble strips, and advisory speeds along curves to increase attentiveness and awareness. The city is also focused on creating a complete bicycle network across Austin using the Safe System Approach to determine the safest facility by separating bicyclists from vehicles in space and time.

Outcomes

The proactive nature of this effort is in alignment with the Safe System Approach. Consistent data monitoring and adaptation is a key element of Austin's Vision Zero Program. The Vision Zero team proactively identifies, addresses risks, and applies appropriate changes to the design of their streets with the understanding that humans can and will make mistakes.

Although many of the engineering efforts are early on in their implementation phases, this proactive, data-driven approach has proven to be an efficient use of resources by providing city staff with the tools to quickly identify priority locations and implement appropriate countermeasures. The city regularly reviews data and provides GIS dashboards to measure safety changes based on improvements being made as part of the Vision Zero program. Early data surrounding the implementation strategies is positive and is continually being monitored by the city.



Source: City of Austin 2022c.

Figure 5. Map. Funded Speed Management Program projects overlaid on percent population non-white.

The city of Austin has recognized the disparities in traffic deaths and severe injuries among racial and ethnic groups, and that the city's historical transportation and land-use decisions have played a substantial role in causing and perpetuating racial inequities. Understanding that Black or African American people are overrepresented among serious injury and fatal crash victims by a factor of 2.2 compared with their share of the Austin population, for example, is a crucial part of reforming the outcomes of the city's Vision Zero Program.[12] The city's Speed Management Program identifies traffic calming projects based on citywide needs, and explicitly incorporates equity criteria into the scoring methodology when identifying project locations.

Additional Information

The city of Austin's 2016 Mobility Bond provided approximately $137 million to local mobility projects, which includes funds designated for the Vision Zero Program. Approximately $15 million of the funding is designated specifically for fatality reduction strategies related to intersection safety and Vision Zero.[13]

The city of Austin uses in-house data analysis created through the Vision Zero program to identify future funding opportunities and leverages funding from the TxDOT Highway Safety Improvement Program (HSIP) to fund safety improvements.

For additional information please contact Lewis Leff, Transportation Safety Officer, at lewis.leff@austintexas.gov or Joel Meyer, Vision Zero Program Manager for the city of Austin, at joel.meyer@austintexas.gov.

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Vision Zero Implementation on Arterial Roadways in the Downtown –Boulder, CO, USA

Key Successes

While Boulder, CO, has reached zero roadway fatalities in some years, they are also implementing many other noteworthy projects through their Vision Zero program. The city is taking a concerted approach to creating more Complete Streets that have space for all types of road users. Some key indications of the city of Boulder's Vision Zero program successes include:

- Boulder achieved zero traffic fatalities in both 2015 and 2017.[1]
- Between 2015 and 2019, Boulder saw a 13 percent decrease in total crashes.[2]
- Support at all levels to implement large-scale roadway redesigns like East Arapahoe Avenue.[3]

Source: City of Boulder 2018.

Figure 1. Illustration. Existing configuration (left) and vision (right) for changes to East Arapahoe Avenue, including bus rapid transit lanes and separated bike lanes.

The Safe System Approach Highlights

Humans make mistakes: In the city of Boulder's annual Safe Streets Report, one of the guiding principles is to design roadways with separated bike lanes and wider sidewalks, which is happening on 30th Street, to accommodate mistakes people may make on roadways.[4, 5]

Humans are vulnerable: The city lowered the default speed limit on local streets to 20 mph through the "20 is Plenty" project and evaluation.[6]

Safety is proactive: The city is proactively installing safety countermeasures by making data-driven engineering changes. On three arterials through the center of the city (Broadway, 28th, and 30th Streets), the city has focused on safety improvements that separate users in space and time, increase visibility, and reduce speeds.

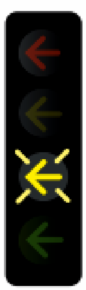
Background

Although the city of Boulder began reporting data on Vision Zero in 2009, it was formally adopted as a part of its Transportation Master Plan in 2014 and serves as a proactive, data-driven approach to increasing the level of safety of their streets.(7) Boulder has a national reputation as a walkable and bikeable city, and one of its core community values is ensuring safe travel for people of all modes. Between 2009 and 2020, Boulder saw 675 serious injuries and fatalities in crashes. For crash data analyzed for the period between 2018 through 2020, the city found that 67 percent of all crashes with severe injuries or fatalities occurred on arterial roadways, so Boulder knew it was crucial to shift its focus to those roadways.(8) Boulder emphasizes in its Vision Zero program that each of these 675 victims are not just numbers, but family members and friends, and their injuries or deaths have a strong impact on the community.

WHAT ARE THE DIFFERENT TYPES OF LEFT-TURN PHASING?

- **Protected:** you turn left while opposing traffic is stopped
- **Permitted:** you turn left when there is a gap in opposing traffic (vehicles, cyclists, pedestrians)

In some cases the City uses a combination of protected and permitted operations at the same signal, and sometimes the signal phasing varies by time of the day to accommodate varying levels of usage.



Why Do We Use a Flashing Yellow Arrow (FYA)?

Research has shown that a Flashing Yellow Arrow is safer than a green ball due to its color (yellow= caution!) and due to the flashing movement, which catches the eye and the attention of motorists. The FYA is now the federal standard and is generally preferred over the use of a green ball to indicate permitted left-turn movements.

The city typically uses protected phasing under certain geometric conditions (e.g., limited sight distance) or if there is a already a crash trend at a a particular intersection. The city also uses protected-only phasing proactively to reduce potential crashes in instances where there are high volumes of bicyclists and/or pedestrians or higher speed vehicles regularly using the intersection.

Source: City of Boulder n.d.

Figure 2. Graphic. Excerpt of different left-turn signal-timing phases being deployed in Boulder to reduce left-turn crashes. The city is implemented flashing yellow arrows (FYA) as a quick-build improvement.

With a holistic, systemwide approach, the city of Boulder continues to set benchmarks and track progress through its Vision Zero Action Plan as well as the identification and implementation of the Low-Stress Walk and Bike Network Plan, which includes phased implementation of recommended bicycle and pedestrian facilities on all roadway classifications within the city.(9) Another way the city works to apply this phased implementation approach is through its Vision Zero Innovation Program (VZIP), which works to install innovative quick-build improvements at a lower cost. The VZIP program is crucial when it comes to the city of Boulder's application of the Safe System Approach as it allows for staff to be proactive when implementing improvements such as curb extensions, traffic calming elements, and pedestrian and bicycle crossing treatments. Through VZIP, projects were deployed along six corridors and 20 other unique locations throughout Boulder in Fiscal Years 2020–2021, and five were in Boulder's urban core.(10) In addition, Boulder is pairing and layering countermeasures based on risk factor assessment to implement safety countermeasures, such as signal timing changes (e.g., flashing yellow arrow, leading pedestrian intervals, no right turn on red, etc.), grade-separated facilities, and business access and transit (BAT) lanes in Boulder, commonly referred to as bus rapid transit (BRT) lanes.

More recently, the city of Boulder announced the Core Arterial Network (CAN) system, where staff is using a data-based approach to create a connected system of protected bicycle lanes, intersection improvements, pedestrian facilities, and transit facility upgrades that will work to prevent severe crashes and improve safety and comfort levels for all users.[11]

Implementation

The city of Boulder's CAN approach identified 13 individual corridors on its arterial roadways to implement mobility enhancements and proactive safety countermeasures. Looking to create a safe and connected system of multimodal facilities along these high-risk arterial roadways, the city council elevated work on the CAN approach as one of its 12 priorities for city department efforts. Both Boulder's Vision Zero Program and CAN approach recognize that although crashes may not have occurred, the concentration of crashes and overlapping risk factors are common in the identified corridors. Working to proactively improve the safety of these corridors, the city has several implementation projects in various phases of completion at intersections on or along Boulder's arterials, including the following:[12]

28th Street

- Addition (and/or repurposing of existing general-purpose lanes) of BRT lanes in both directions
- Completion of the gaps in the existing multi-use path along 28th Street to provide a continuous, 10-foot-wide facility
- Addition of raised driveway crossings along the multi-use path
- Installation of colored pavement and green conflict markings in high-conflict areas
- Installation of street trees and landscape buffers between the street and multi-use path

30th Street

- Lengthened pedestrian clearance times
- Conversions of left-turn operations to flashing yellow arrows
- Adjustment of left-turn phasing from protected/permitted to protected-only during either peak travel times or always
- Installation of vertically separated bike lanes
- Construction of underpasses for pedestrians and cyclists, along with a fully protected intersection

Broadway

- Conversion of left-turn operations to flashing yellow arrows
- Addition of more signalized right turn lanes to avoid conflicts with a multi-use path
- Installation of pedestrian head-starts
- Rebuilding of traffic signals to provide protected left-turn phasing

Source: City of Boulder 2022d.

Figure 3. Image. Rendering of 30th Street and Colorado Avenue intersection improvements (protected intersection, underpasses) under construction.

Outcomes

The work being done in Boulder applies the Safe System Approach to recognize that humans make mistakes and uses interdisciplinary resources to proactively improve the design of arterials to accommodate these mistakes. Like many small or mid-size cities, the arterials in Boulder run right through the core of the city and serve as major motor vehicle, bicycle, and pedestrian thoroughfares. With an abundance of mixed-use development occurring along these roadways, it is important to accommodate and ensure the safety of all users. Boulder is looking at providing safe accommodations for all modes by providing separated facilities.

Many of these improvements are early in their implementation, but preliminary evaluations are showing dramatic decreases in crash rates at various intersections on these arterials from countermeasures such as flashing yellow arrow and red-light running cameras. In addition to the CAN program, Boulder is also working to update the city's design and construction standards such that the technical standards for designing and constructing projects is aligned with its Vision Zero goals.(13) Boulder is continually working to enhance community awareness and engagement, have utmost transparency, and refine its performance metrics.

Additional Information

Many of the projects completed in Boulder have been funded through Highway Safety Improvement Program (HSIP) funds. For additional information, please contact Devin Joslin, Principal Traffic Engineer, for the city of Boulder at joslind@bouldercolorado.gov, or visit https://bouldercolorado.gov/services/vision-zero and https://bouldercolorado.gov/services/safe-streets-report for the 2022 Safe Streets Report.

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Cambridge Combines Planning and Projects that Increase Safety for All – Cambridge, MA, USA

Key Successes

In 2018, the city of Cambridge, MA, began applying the Safe System Approach and released its Vision Zero Action Plan.[1] The city's approach to safe mobility has focused on increasing multimodal options. In the last few years, Cambridge has worked to increase bicycling infrastructure and has seen an increase in bicycle use and improvements in safety. The success of the Safe System Approach in Cambridge can be seen in the city's Western Avenue project, which helped spur the city's increased focus on bicycle facilities as a safety strategy. Some key indications of the city of Cambridge's Vision Zero program successes include the following:[2]

- Western Avenue has seen speed reductions of 25 percent and fewer severe injury crashes while doubling to quadrupling the number of people bicycling and walking after separated bicycle lanes were installed.
- An additional 47 lane miles of bicycle infrastructure from 2004 to 2019 were added and bicycle ridership increased by 212 percent over the same period.
- A 36-percent decrease in bicycle crash frequency rates as bicycle miles traveled increased by 190 percent in 15 years.

Source: City of Cambridge 2017.

Figure 1. Image. Bicycle amenities in Cambridge.

The Safe System Approach Highlights

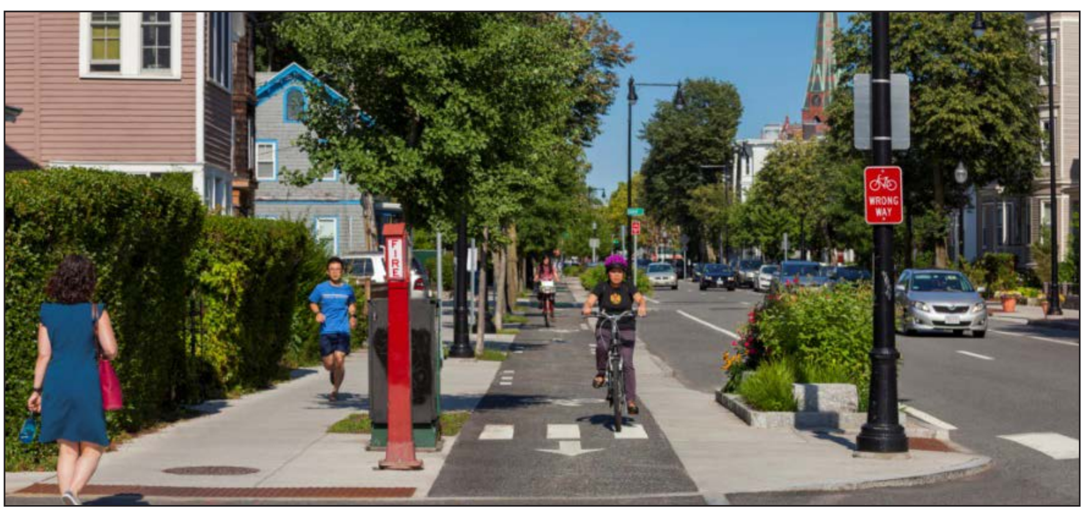
Humans make mistakes: The city of Cambridge is designing facilities to separate users in space so that when someone makes a mistake it does not result in death or serious injury. Cambridge has focused on building bicycle facilities that are demonstrably safer and more comfortable for all ages and abilities throughout the city. The city's Bicycle Network Vision identifies specific corridors for separate bike lanes.(3)

Safety is proactive: By using a level-of-comfort analysis, which correlates to a level-of-stress analysis, to inform the vision for its bicycle network, the city is focused on improving safety at locations with crash-risk factors and where increasing bicycling is needed, instead of waiting for crashes to occur at specific locations.(4)

Responsibility is shared: One action item in the city of Cambridge's Vision Zero Plan is establishing the Cambridge Community Response Network (CCRN) which includes the public health department, the police department, the department of human service programs, peace commission, emergency communications, and the public schools, to respond to the immediate and long-term impacts of trauma on a community.(5) Trauma includes traffic fatalities and serious injuries, and the CCRN shares responsibility in responding after an incident and providing input on roadway design to prevent future incidents.

Background

Cambridge is a dense and growing city near Boston, home to four higher education institutions (Harvard University, the Massachusetts Institute of Technology, Lesley University, and Hult International Business School), and a hub of innovation and scientific research. From 2010 to 2015, Cambridge took an opportunity to combine sewer replacement and reconfiguration work on Western Avenue with installation of a sidewalk-level separated bicycle lane, curb extensions, raised crosswalks, and other measures to meet community goals of ensuring the corridor is safe for all users and has the "appropriate traffic speed."(6) The Western Avenue project was a $15 million sewer upgrade and road reconstruction project. By its completion, the project was well-loved by city residents and received national accolades such as the #1 Best New Bike Lane of 2015 by the nonprofit organization People for Bikes.



Source: Anthony and Halvorson | Tighe & Bond Studio n.d.

Figure 2. Image. Western Avenue Reconstruction Project with sidewalk-level separated bicycle lane and curb extensions.

The Western Avenue project demonstrated the value of incorporating high-quality bicycle facilities into roadway projects on major streets. The project helped spur an increased focus on bicycle facilities as part of the city's traffic safety strategy. This increased focus is reflected in the 2015 Cambridge Bicycle Plan, which, guided by its goal of creating a "transportation system that is safe for users of all ages and abilities," was the city's first Bicycle Plan to propose a 115-mile Bicycle Network Vision of low-stress bikeways such as off-street paths, separated bicycle lanes, and low-volume low-speed streets which connected commercial areas and key destinations.(7) The Plan also made building new facilities, as identified in the Bicycle Network Vision, a key goal moving forward.

To elevate the role of public safety in transportation, in 2016, Cambridge adopted Vision Zero and subsequently implemented citywide reductions in speed limits in conjunction with newly adopted State regulations allowing lower speed limits in urbanized areas of Massachusetts. In 2019, the Cambridge city Council adopted a first-of-its-kind Cycling Safety Ordinance, which requires the city to incorporate separated bicycle lanes identified in the Bicycle Network Vision whenever those streets that have been designated for greater separation are up for reconstruction.(8) This was seen as a key step towards eliminating vulnerable road users' severe injuries and fatalities in Cambridge.(9)

Implementation

From the implementation of the Western Avenue bicycle infrastructure, Cambridge has continued incorporating groundbreaking practices that put safety first at the project, program, and policy level while building out the city's bicycle network:

- **Using Bicycle Level-of-Comfort (LOC) analysis to build a network vision that is safe, comfortable, and connected.** In its bike plan, Cambridge employs an LOC analysis calibrated to the unique circumstances of the city to identify the streets that are safe and comfortable for all ages and abilities and the gaps in the network created by stressful and unsafe roads.(10)
- **Codifying into local law the use of road reconstruction opportunities for bicycle network implementation.** The Cycling Safety Ordinance adopted by the Cambridge city Council in 2019 requires the city to build out the 25 miles of separated bicycle lanes identified in the Bicycle Network Vision whenever those streets are up for reconstruction.(11) A 2020 amendment to the ordinance codified a six-year timetable for implementation and the option of using quick-build materials to meet deadlines when reconstruction isn't planned.(12)
- **Prioritizing the implementation of bicycle infrastructure that is safer by reducing vehicle speeds and providing separation where possible.** As a result of the Cambridge Bicycle Plan and the Cycling Safety Ordinance, Cambridge has primarily focused on installing new bicycle infrastructure along the corridors identified in the Bicycle Network Vision using treatments that create safer conditions for everyone by changing the geometry of the street. River Street, the eastbound half of the one-way couplet with Western Avenue, was slated to start reconstruction in 2022, and it, too, will have the sidewalk-level separated bicycle lane, curb extensions, a bus lane, and other countermeasures that have proven effective at keeping vehicle traffic closer to the posted speed limit.(13) This will create safer conditions for all people, including those who walk, bicycle, and take transit.
- **Establishing a rapid response protocol which includes the Cambridge Police Department.** The rapid response team completes a site visit at the locations of any fatality or serious injury within 3 business days of the crash. The team evaluates and analyzes the crash site, conditions, and known details of each incident to make recommendations to the city for action, including measures such as street design changes.(14)

Outcomes

The city of Cambridge was able to leverage its success with the Western Avenue project to increase focus on high-quality bicycle facilities as a safety strategy. The city's emphasis on safety includes a bicycle network composed of off-street paths, separated bicycle lanes, and low-speed low-volume streets connecting key origins and destinations in its Bicycle Network Vision. This emphasis, along with implementing other measures in line with the city's Vision Zero commitment, may be behind the reduced severity of injury among bicyclists in reported crashes. Since the 2015 Cambridge Bicycle Plan, 67 percent of the separated bicycle lane miles built in the city were built on streets that were part of the Bicycle Network Vision. At the network level, the city has expanded the number of miles of bicycle facilities from 70 miles in 2014 to 94 miles in 2019 (a 34-percent increase), which coincided with an increase of over 25 percent in the number of people bicycling over the same period. While the number of people bicycling and miles traveled has gone up, the number of bicycle crashes has not, which means that the rate of crashes has gone down.

In its 2020 Bicycle Plan update,[(15)] the city of Cambridge estimates that the bicycle crash frequency rate in Cambridge has decreased by 36 percent from 2004 to 2019 while bicycle miles traveled have gone up 190 percent over the same period. The 2020 Bicycle Plan reports that of all bicycle crashes reported, non-incapacitating injuries dropped from 45 percent during 2004–2012 to 8.8 percent during 2015–2019, and incapacitating injuries (where the bicyclist was not able to move post-crash) dropped from 5.2 percent to 1.2 percent over the same period. Conversely, crashes where no injury was reported by the bicyclist went up from 18.3 percent to 49.8 percent.

A post-construction evaluation report for Western Avenue completed in 2019 suggests that providing grade and buffer-separated facilities that separated those walking and rolling from the vehicle traffic may be partially responsible for the reduced severity of crashes involving pedestrians and bicyclists. Using EMS calls as a proxy for crash severity, the Western Avenue Post Construction Evaluation Report found that the number of EMS calls to attend bicyclists and pedestrians post-crash on Western Avenue has gone down from six to four in the two years before and after reconstruction despite a doubling to a quadrupling of bicyclists and pedestrians on the corridor after the reconstruction. This suggests the overall severe crash rate on Western Avenue has decreased. The report also found that vehicle speeds have also decreased by 25 percent, with the 85th-percentile speed at 32 mph before and 28 mph after reconstruction, closer to the 25 mph posted speed limit which was unchanged.[(16)] The success of projects like Western Avenue and the clear vision provided by the Cambridge Bicycle Plan provided the impetus for the city's Cycling Safety Ordinance, which has guided the construction of over 6 miles of separated bicycle lanes since its enactment in 2019, with an additional 4.5 miles in various stages of planning and construction (as of this writing).[(17)]

Additional Information

For more information about the Cambridge Bicycle Plan, contact Cara Seiderman, Transportation Program Manager with the city of Cambridge at csneiderman@cambridgema.gov. For more information specifically about Western Avenue, contact Bill Deignan at wdeignan@cambridgema.gov.

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Milwaukee Avenue Complete Streets Project – Chicago, IL, USA

Key Successes

Following installation of separated bike lanes, pedestrian crossing improvements, and a reduction in the posted speed limit, traffic crashes on Milwaukee Avenue between Western Avenue and California Avenue in Chicago, IL, declined dramatically for all road users. A comparison between before and after installation traffic crash data shows the following:[(1)]

- A 57-percent reduction in automobile injury crashes
- A 71-percent reduction in bicyclist injury crashes
- Zero pedestrian crashes and zero dooring crashes after the improvements

The Safe System Approach Highlights

Death/serious injury is unacceptable: The city adopted a Vision Zero action plan in 2017.[(2)]

Humans are vulnerable/ redundancy is crucial: The plan entailed speed reductions (reduction of posted speed limit to 20 mph), separation of road users in space (separated bike lanes).

Responsibility is shared: The Chicago Department of Transportation (CDOT) and the city's 1st Ward worked with the local community and business stakeholders to identify a positive redesign of the area.

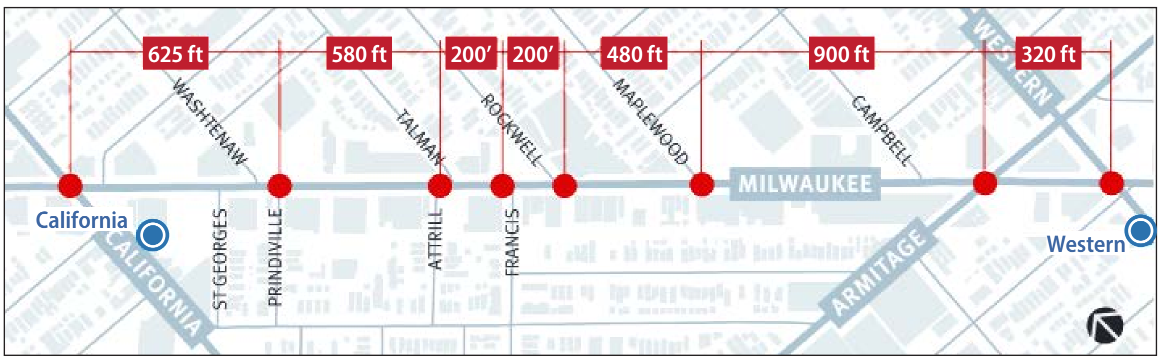
Background

Milwaukee Avenue is a key diagonal street in the city of Chicago, carrying vehicles, bicycles, scooters, buses, and pedestrian traffic. The study corridor covers approximately 0.75 miles of Milwaukee Avenue between Western Avenue and California Avenue in the Logan Square neighborhood. Land uses along the corridor are mostly residential and commercial, including retail, thrift/discount, restaurant/bar, commercial service, and mixed commercial.

In 2017, the city of Chicago's Vision Zero Action Plan identified Milwaukee Avenue as a high-crash corridor. From 2012 to 2016, the corridor averaged 94 crashes per year, including 27 injury crashes.[(3)] Pedestrians and bicyclists were disproportionally injured in crashes, accounting for two-thirds of all injury crashes. CDOT worked to create a safer Milwaukee Avenue between Western Avenue and California Avenue. The goal of the project was to make the street more comfortable and accessible for people walking, biking, driving, and using transit. CDOT worked with local stakeholders to identify a positive redesign of the area, which considered the corridor's existing conditions, summarized below: [(4)]

- Low on-street parking occupancy: A parking survey along the study corridor showed a 46 percent on-street parking occupancy on weekdays and a 63 percent on-street parking occupancy on Saturdays.
- High vehicular speeds: A 24-hour speed study conducted along Milwaukee Avenue showed that 500 vehicles were driving faster than 30 mph and the top speed was 60 mph.

- Pedestrians and bicyclists disproportionately injured in crashes: From 2012 to 2016, the corridor averaged 94 crashes per year, including 27 injury crashes. Two-thirds of injury crashes involved pedestrians and bicyclists.
- Large gaps between crosswalks: CDOT had received numerous citizen complaints regarding how difficult it was to cross Milwaukee Avenue to access businesses and get to the transit stops. There were large gaps between designated pedestrian crossings along Milwaukee Avenue between Western Avenue and California Avenue, as shown in Figure 1, the largest gap being 900 feet.(5)
- Fast bicycling growth along Milwaukee Avenue, especially for people bicycling to work: Based on the 2013-2017 Census Data, the change in mode share along the study corridor included a 4.4 percent reduction in auto use, 5.3 percent increase in transit use, 1.5 percent increase in walk, and 23.5 percent increase in bicycling.(6) Further, there was an 83 percent increase in bicycling to work along the study segment, compared to a 24 percent increase in Chicago.(7)



Source: CDOT 2022.

Figure 1. Diagram. Gaps between crosswalks along Milwaukee Avenue between Western Avenue and California Avenue.

Implementation

The implementation of Milwaukee Avenue improvements between Western Avenue and California Avenue was led by CDOT and the city of Chicago's 1st Ward. CDOT began working with the local community to identify a positive redesign of the area. The community engagement process included door-to-door meetings with businesses along Milwaukee Avenue to introduce the project, learn about business operations, and listen to concerns. Discussions with the local community and stakeholders yielded additional questions and concerns that were used to make changes to the final design plans.(8)

The Milwaukee Avenue improvements between Western Avenue and California Avenue included northbound and southbound separated bike lanes to provide more separation between bicyclists and vehicular traffic, bump outs to reduce crossing distances, crosswalks to provide additional crossing opportunities, and a 20-mph posted speed limit to complement the infrastructure changes and encourage safe driving speeds. Expanding the low-stress bike network is a priority for CDOT and Milwaukee Avenue and is an example of successfully accommodating the different uses of the street and improving access for those most vulnerable. Figure 2 shows an example of the corridor before and after the proposed improvements.

Source: CDOT 2022.

Figure 2. Images. Existing conditions and proposed improvements along Milwaukee Avenue between Western Avenue and California Avenue.

The order of construction of project elements began with separated bike lanes and ended with crosswalk installation. The separated bike lanes included plastic curbs and posts, which are more lightweight and affordable than the concrete barriers or series of bollards typically used to separate cyclists from drivers. In addition, green pavement markings were added along the separated bike lanes. Figure 3 illustrates a segment of the separated bike lanes along Milwaukee Avenue.

Source: CDOT 2022.

Figure 3. Image. Plastic curbs and green bike boxes at the Milwaukee Avenue and California Avenue intersection.

While parking on Milwaukee Avenue was restricted during construction, the street and businesses remained accessible. More than 35 new bike racks were installed between California Avenue and Western Avenue to ensure ample bike and scooter parking. In addition to pedestrian and bicyclist improvements, bus floating islands are being constructed at various intersections to improve transit operations, transit customer experience, and to route people biking behind the bus stops.

Milwaukee Avenue on-street parking was consolidated to one side of the street to accommodate the safety improvements. Parking reduction accommodated as many businesses as possible based on discussions with local business owners. Further, no residential parking was removed, no changes were made to existing residential permit zones or access into neighborhoods, and loading and standing zones for businesses remained.

Outcomes

The improvements along Milwaukee Avenue between Western Avenue and California Avenue resulted in higher comfort for everyone living, working, and visiting Milwaukee Avenue. The improvements enhanced business access for all modes and provided better access to transit stops via new crosswalks. The separated bike lanes are more comfortable for new bike riders and helped increase bike ridership around the neighborhood and among bike commuters.

CDOT evaluated crash data before (1-year average, 2012–2016) and after (2021) the improvements were implemented. Safety outcomes included a 57-percent reduction in automobile injury crashes and a 71-percent reduction in bicyclist injury crashes. Further, zero pedestrian crashes and zero dooring crashes were reported after the improvements.[9]

Additional Information

Pedestrian and bicyclist improvements along Milwaukee Avenue between Western Avenue and California Avenue were implemented during the summer of 2020 and included separated bike lanes, pedestrian crossing improvements, and reduced posted speed limit. For additional information, contact David Smith, CDOT Director of the Complete Streets Team at david.smith3@cityofchicago.org.

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2020 Vision Zero: Vulnerable Road User Improvements – Fremont, CA, USA

Key Successes

Since adopting Vision Zero in 2015, Fremont has worked to improve safety for all road users by applying a Safe System Approach to street design, operations, and public education.(1) In 2016, a data-driven action plan was adopted for the year 2020. This case study focuses on vulnerable user success stories in the context of the Safe System Approach in an urban core and describes accomplishments related to safe and complete streets, as shown in Figure 1; safe crossings; brighter street lighting; and safe routes to schools in Fremont. When comparing crash data between 2013 and 2015 (before the Vision Zero policy) and between 2018 and 2020 (after the Vision Zero policy), Fremont's efforts resulted in the following safety outcomes:( )2

Source: City of Fremont 2021.

Figure 1. Image. Protected Intersection in Fremont, CA, at Civic Center Drive and Walnut Avenue.

- A 32-percent decrease in pedestrian fatal and serious injury crashes
- A 23-percent decrease in bicyclist fatal and serious injury crashes
- A 36-percent decrease in fatal and serious injury crashes during dark conditions
- A 67-percent decrease in youth aged 15 or younger fatal and serious injury crashes

The Safe System Approach Highlights

Examples of how elements of the Safe System Approach are incorporated in the Fremont Vision Zero policy are shown below:

Death/serious injury is unacceptable: The city adopted a Vision Zero policy in 2015.

Humans make mistakes/humans are vulnerable: Planned improvements included separation of road users in space (buffered and separated bike lanes, protected intersections).

Responsibility is shared: The Vision Zero action plan was a coordinated effort that involved the city of Fremont Public Works Department, the city manager, the community, the police department, local advocates, educational institutions, and elected officials.

Safety is proactive: The systemic approach was applied at locations where improvements were needed based on the risk of future crashes. For example, the city installed pedestrian countdown signals at all signalized intersections citywide and short- and long-term measures to improve mid-block crossings.

Redundancy is crucial: Improve pedestrian safety by updating signals, street lighting, and pedestrian crossings.

Background

The city of Fremont has a population of 240,000 and is in the Silicon Valley area of California. During the 2013–2015 period, Fremont experienced a concerning rise in traffic fatalities and severe injury crashes, particularly involving pedestrians, youth, and seniors. The city's organizational focus on traffic safety began in 2015 with the adoption of a Vision Zero policy. city staff from the police department and the public works department prepared a data-driven action plan for the year 2020.(3)

Implementation

The Fremont Vision Zero 2020 Action Plan, approved in 2016, focused on pedestrian countdown signals, brighter street lighting, and safer and more accessible pedestrian crossings. The main action items for this preliminary plan were a coordinated effort and involved the following:

- **Organization practices:** In Fremont, the offices of transportation engineering and street maintenance as well as the city's pavement maintenance program are all organized within the public works department, which reduces barriers to collaboration. This collaboration enabled the implementation of quick-build projects, which used materials that were inexpensive and easy to install.
- **Partnerships:** The police department and transportation engineers meet monthly to share information. The fire department works with public works to ensure that narrower street designs to manage speeds do not impede emergency response times. The city has also partnered with healthcare providers and the school district in Fremont.
- **Using data for high-impact work:** Fremont created a map of high-crash roads to focus infrastructure projects. The city also provides systemic responses and identifies locations where improvements are needed based on a risk for a future crash.
- **Updating plans and community engagement:** The city has a Mobility Action Plan, a Bicycle Master Plan, a Pedestrian Master Plan, and Safe Routes to Schools Plans that provide location-specific recommendations and identify priority projects. The community is always engaged in the planning process through meetings, online surveys, and coordination with the city's Mobility Commission.
- **Safety improvements:** The 2020 Vision Zero Action Plan was mostly achieved with no new city funding commitments and no new dedicated staff positions. The program was initiated by reallocating existing funding resources away from projects that did not serve Vision Zero goals and reshuffling existing staff assignments. Therefore, early projects focused on low-cost improvements; creative methods to finance projects; and the use of student interns for data collection and analysis, video production, and design drafting. Recently, the city has received grant funding that enabled it to implement higher cost projects such as traffic signal installations, raised bicycle tracks, and protected intersections.
- **Community:** "Safety" was adopted as the 2016 theme for the city's outreach booth at community events.
- **Elected Officials:** Vice Mayor Sue Lee Chan started a speaker series to discuss Vision Zero with everyone that was interested.

Outcomes

In 2016, a data-driven action plan was adopted in Fremont for the year 2020. In 2021, the city released a safety status report comparing average crashes during the 2013–2015 period (before the Vision Zero policy) with average crashes during the 2018–2020 period (after the Vision Zero policy).[4] Accomplishments resulting from applying the Safe System Approach in an urban core following the implementation of the data-driven action plan include the following:

- **Safe and complete streets:** Fremont has restriped 40 miles (47 percent of its arterial roadways) since 2015. The restriping included reducing travel-lane widths to 10 feet and adding enhanced bike facilities, such as buffered and separated lanes. Further, five intersections have been rebuilt as protected intersections, with five more in construction, and more than 30 quick-build bulb-outs have been installed. Intersection improvements were implemented as both quick-build projects and as full reconstruction projects with upgraded traffic signal systems. The new intersections have tighter radii, which shorten crossing distances for bicyclists and pedestrians and force drivers to take turns at slower speeds. Also, weaving maneuvers between bicyclists and vehicles were eliminated and sight lines were improved at the protected intersections.
- **Safe crossings:** The city installed pedestrian countdown signals at all signalized intersections citywide. In addition, Fremont enhanced its 40 mid-block crosswalks on multilane, higher speed roadways with both short- and long-term measures. Short-term measures included high-visibility crosswalk striping, advance yield signage and markings, and striping and channelizer posts between travel lanes. Long-term countermeasures included rectangular rapid flashing beacons, pedestrian signals, median refuge islands, and bulb-outs.
- **Brighter street lighting:** The city converted approximately 16,000 streetlights from the standard “yellow” sodium vapor lights to brighter “white” LED lights.
- **Safe routes to schools:** Safety improvement plans were developed for all the 40 public schools citywide as a result of a joint effort from the city and Fremont Unified School District. The improvements included new all-way stops, high-visibility crosswalks, parking restrictions, enhanced warning signage, and bulb-outs delineated with paint and plastic delineators.

The safety effectiveness of Fremont’s vulnerable road user accomplishments in the context of the Safe System Approach in an urban core resulted in a decrease in pedestrian and bicyclist fatal and serious injury crashes, a decrease in fatal and serious injury crashes during dark conditions, and a decrease in fatal and serious injury crashes among youth aged 15 or younger.

Additional Information

The Fremont Vision Zero 2020 Action Plan, approved in 2016, was mostly achieved with no new city funding commitments and no new dedicated staff positions. The program was initiated by reallocating existing funding resources away from projects that did not serve Vision Zero goals and reshuffling existing staff assignments. Therefore, early projects focused on low-cost improvements, creative methods to finance projects, and the use of student interns for data collection and analysis, video production, and design drafting, which allowed work to start immediately rather than waiting for the regular budget process.

Recently, the city of Fremont received grant funding that enabled the city to implement higher cost projects, such as traffic signal installations, raised bicycle tracks, as shown in Figure 2, and protected intersections. New funding for transportation safety projects was also made possible due to the approval of transportation tax programs in 2014 and in 2017.

Source: City of Fremont 2021.

Figure 2. Image. Raised bicycle track along Walnut Avenue in Fremont.

For additional information, contact Hans Larsen, City Public Works Director (hlarsen@fremont.gov).

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MassDOT Applies the Safe System Approach in Policies, Programs, and Practices – Massachusetts, USA

Key Successes

The Massachusetts Department of Transportation (MassDOT) has a twofold approach to safety. First, the agency uses a data-driven process for identifying locations with high-crash rates and those at high risk of crashes that are eligible for safety enhancements across the State, regardless of jurisdiction. Second, the agency provides several resources for local jurisidictions to use toward additional safety projects. Since these resources have been recently put into practice, not many engineering outcomes are yet apparent. However, there have already been some key successes, which include the following:

- The data-driven approach in the publication *MassDOT Safety Alternatives Analysis Guide*, which supports MassDOT, regional offices, local agencies, and consultants in the development and selection of safety-focused and cost-effective alternatives.(1)
- While the results are preliminary, an illustrative urban area project—the Kelley Square intersection—shows crashes (both injury and property damage only crashes) have dropped 35 percent since the improvements were implemented, despite only a 17-percent drop in crashes elsewhere in the city and an increase in traffic over the same period.(2)

The Safe System Approach Highlights

Responsibility is shared: MassDOT's approach focuses on a data-driven process to fund safety projects on roadways statewide while also recognizing its role as a provider of resources to local agencies so changes can be made at local levels. One of the resources that MassDOT makes available for both its own use as well as public and local agency use is the *Safety Alternatives Analysis Guide*, which supports regional offices and local agencies in developing and selecting safety-focused and cost-effective alternatives for projects.(3)

Safety is proactive: MassDOT's Safety Analysis Tools Module provides interactive online dashboards where users can easily identify roadway segments that are ranked through a risk-based screening analysis for several emphasis areas and go beyond simply addressing crash "hot spots."(4)

Redundancy is crucial: Safety projects, such as Kelley Square, include multiple safety countermeasures to increase safety of all road users and reduce conflicts and speeds in urban cores, metropolitan cities, and rural town centers across the State.

Humans are vulnerable: Speed management in Massachusetts recognizes that a layering of strategies is needed to create safe speeds for all road users. MassDOT has incorporated a five-step recommended process to implementing speed management in communities. These steps include collecting and analyzing data, establishing a target speed, designing speed control, and raising awareness.

Sources: MassDOT 2020b (top) and VHB n.d. (bottom).

Figure 3. Images. Before (top) and After (bottom) photos of intersection safety improvements that apply the Safe System Approach in an urban core at Kelley Square.

Background

MassDOT has fundamentally adopted the Safe System Approach at all levels to systemically address crashes across its broad jurisdiction, particularly in urban areas where factors leading to crashes are more complex. Since 2006, when it released its *Project Development and Design Guide*, MassDOT has made multimodal consideration—defined as "[ensuring] that the safety and mobility of all users of the transportation system (pedestrians, cyclists, and drivers) are considered equally through all phases of a project so that even the most vulnerable (e.g., children and the elderly) can feel and be safe within the public right of way"—a strong guiding principle for all of its projects.[(5)]

This emphasis on safety across all modes has carried through to this day, with the principles and elements of the Safe System Approach being woven into the update of MassDOT's latest Strategic Highway Safety Plan (SHSP), which is currently underway. Previously, specific elements of the Safe System Approach were used by MassDOT. In 2018, the agency guided conversations with 250 stakeholders grouped into 14 defined emphasis areas. For the soon-to-be updated SHSP, the Executive Leadership Committee opted for using a framework based on the Safe System Approach, which is instrumental in breaking down silos that often occur when stakeholders communicate around a particular emphasis area (e.g., speeding, aggressive driving, pedestrian crashes, large truck-involved crashes, lane departure crashes, and so on). The breaking down of silos is helping to ensure success when stakeholders across the State have a voice in updating the criteria for selecting strategies and actions to include in the SHSP.

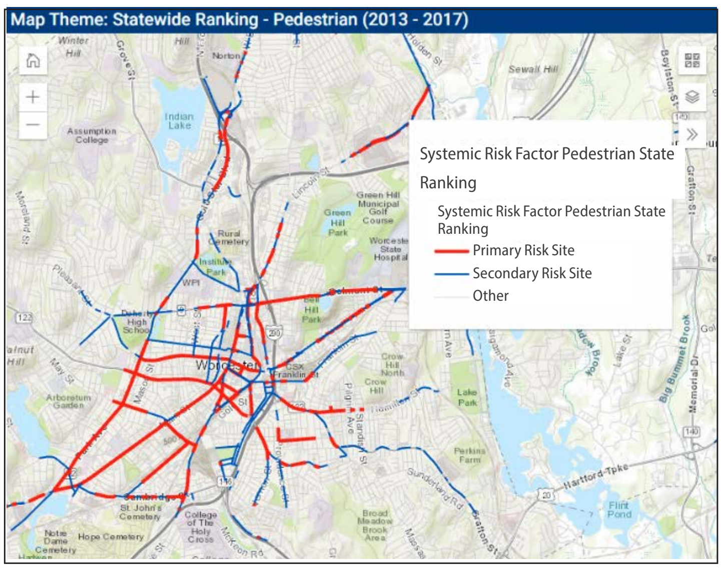
Source: City of Newton n.d.

Figure 4. Image. Rendering of proposed changes to Commonwealth Avenue with new sidewalk and two-way separated bike lanes.

Implementation

Included in MassDOT's safety program are policy and procedure tools that provide resources for municipalities to adopt and implement Safety System Approaches. These policy and procedural tools include the following:

Safety Analysis Module in IMPACT Crash Data Portal:[6] MassDOT recently implemented a new module of safety analysis tools in its crash data portal, which is used by stakeholders to locate intersections with both high-crash rates and a high risk of crashes as well as segments that could be eligible for HSIP funding. Network screening tools highlight the top 5 percent and 10 percent of segments based on reported crashes and risk factors, respectively, both statewide and by MPO. A powerful tool for developing crash trees and proportions testing allows users to easily create custom reports detailing common and overrepresented crash types at the citywide, corridor, or intersection level. These tools have proven very popular with MassDOT regional offices, MPOs, and municipal staff to help guide conversations about traffic safety issues with constituents at the local level.



Source: MassDOT n.d.

Figure 5. Map. Safety analysis module depicting corridors at high risk for pedestrian crashes.

Safety Alternatives Analysis Guide:[7] MassDOT published the Safety Alternatives Analysis Guide in October 2021 to support MassDOT, regional offices, local agencies, designers, and consultants in the development and selection of safety-focused and cost-effective alternatives for projects, particularly if they are seeking HSIP funds. While the guide can be used across land-use contexts from urban to rural, it augments typical intersection control evaluations (ICE). It provides a method to calculate crash frequency even where national and State-calibrated safety performance functions are not available. The guide incorporated an economic analysis step, where the cost of each alternative is compared to their estimated system-wide benefits using Massachusetts-adjusted comprehensive crash costs.

To go beyond the use of the *Safety Analysis Alternatives Guide* at irregular intersections, MassDOT recently used the Safe System Approach for the development of alternatives on several projects. One of these projects was Commonwealth Avenue in Newton which included the Commonwealth Avenue (MA 30) intersection with Auburn Street and Oakland Avenue. The project is under design to include a continuous green intersection in addition to two-way separated bike lanes and installation of several crossings with Rapid Rectangular Flashing Beacons (RRFBs).

Kelley Square Improvement Project:(8) Kelley Square was an unsignalized, seven-leg, high-crash intersection in Worcester, MA, that was the top crash location in the city and #5 in the state. MassDOT led a redesign that converted the square into a hybrid roundabout, with most of the work substantially completed by January 2021. The preliminary data indicate crashes (both injury and property damage only crashes) have dropped 35 percent from before the improvements were put in place to after the improvements had been put in place, as compared to only a 17-percent drop in crashes elsewhere in the city and an increase in traffic over the same period.[2] The redesign has won awards for community engagement and engineering excellence for increasing safety, enhancing traffic flow, and creating a more walkable and bikeable environment, all in a challenging urban space. For more information about key safety elements of the project, view the November 2020 Kelley Square Newsletter.(9)

Major elements of the Kelley Square project include the following:(10)

1. Reconstruction of Kelley Square as a hybrid roundabout
2. Madison Street:
    - Adding parking to the road's north side
    - Improving landscaping and street lighting along the road
    - Constructing a shared-use path
3. Green Street:
    - Improving landscaping and street lighting along the road
    - Constructing a shared-use path
4. Harding Street:
    - Improving landscaping and street lighting along the road
    - Constructing a shared-use path
    - Constructing a bicycle lane leading into Kelley Square
    - New roundabout at the intersection of Arwick Ave., Millbury St., and Harding St.
5. Reversing the direction of Millbury St. and Harding St. to work with the Roundabout in Kelley Square

Source: MassDOT 2020b.

Figure 6. Project elements of the Kelley Square project in Worcester, MA.

Equity Considerations in Pedestrian Safety: As part of the U.S. DOT Safety Data Initiative and MassDOT's SHSP Emphasis Areas, MassDOT has been working to identify safety improvements to help produce more equitable outcomes for pedestrian safety and mobility based on risk factors of pedestrian deaths, such as roadway and infrastructure factors like speed limit and number of lanes. According to FHWA's July/August 2022 Innovator Newsletter, "MassDOT found the majority of fatal and serious injury pedestrian crashes occurred on roads that had posted speed limits of 35 miles per hour and less and were two-way with an undivided configuration. [Additionally, if] the road segment is located within an area that has a high percentage of low-income households, a higher percentage of non-English speakers, or lower employment rates, the road segment has an elevated risk."(11) This safety and equity analyses is helping MassDOT identify high-impact safety and equity projects where risk and need are greatest statewide. Read more about this work in the full MassDOT *IMPACT Phase II – Identification of Risk Factors for SHSP Emphasis Areas Pedestrian Crashes*.(12)

Achieving Target Speeds: In November 2016, the Massachusetts State Legislature passed a law that allows municipalities to lower speed limits below the statutory speed limit of 30 mph to 25 mph in areas that are defined as thickly settled based on the density of businesses or residences, and municipalities can unilaterally opt in to do so in accordance with a local ordinance, notifying MassDOT of the change in the statutory speed limit and posting it at the jurisdictional boundaries. The law also allows for the creation of safety zones where the posted speed limit can be reduced to 20 mph. Since the law was passed, 58 municipalities across the State have opted into lowering speed limits in their thickly settled areas. The largest cities within the Commonwealth of Massachusetts, such as Boston and Springfield, enacted similar local laws within a year of the State law being passed. More recently, smaller urban areas, such as Amesbury and Winthrop have made the switch to lower speed limits locally, with both communities enacting their local ordinances in 2021.

Nationwide, there is limited data on the effectiveness of solely lowering posted speeds to reduce motorists speeding. MassDOT recognizes that speed-limit reductions are most effective when instituted in tandem with road geometry changes that provide self-explaining roads and help achieve target speeds. Therefore, there is continued need for data on the effects of speed-limit reductions in thickly settled areas alone.

Given that lower speeds are a critical element of the Safe System Approach and that speed-limit changes work best when enacted in concert with changes to roadway geometry, MassDOT has created a detailed speed management webpage to provide step-by-step assistance on how to implement safer speeds in Massachusetts communities.(13) This webpage also includes a roadway treatment toolkit that MassDOT recently created for municipalities and local stakeholders about how to layer speed management treatments that control speeds and create separation through roadway treatments.(14)

Outcomes

Overall, the efforts of MassDOT to increase the safety of the State's transportation system using elements of the Safe System Approach have contributed to it being a State DOT known for promoting the safety of all road users and providing technical assistance to its local agencies. With a fatality rate of 0.51 deaths per 100 million vehicle miles traveled (VMT), 54 percent lower than the nationwide average in 2019, Massachusetts is the State with the lowest fatality rate from motor vehicle traffic crashes, according to the latest data from FARS.(15) From 2012 to

2019, Massachusetts saw consistent year-to-year reductions in serious injury crashes that add up to an overall decrease of a 23 percent, even as VMT has gone up consistently over the same period.[16]

Additional Information

For more information about MassDOT safety programs, contact Bonnie Polin, State Safety Engineer at MassDOT at Bonnie.Polin@dot.state.ma.us.

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Using Vision Zero as a Goal and Putting Actions in Motion to Eliminate Traffic Deaths in the Downtown Core – Minneapolis, MN, USA

Key Successes

The city of Minneapolis, MN, has adopted a goal of Vision Zero by 2027 and has started to apply the Safe System Approach as a means to achieve zero traffic deaths. In 2017, Minneapolis adopted its Vision Zero resolution. The city takes a people-focused approach to safe mobility and pays particular attention to the disparities low-income communities and communities of color are experiencing with regards to traffic deaths and serious injuries.

Key successes of the city's Vision Zero program include the following:[1]

- A key performance metric to monitor the percentage change in traffic stops among people of color.
- A 49-percent decrease in pedestrian- and bicycle-related crashes in 2020 compared to the 2016–2019 average.
- A 17-percent decrease in the total number of traffic deaths and severe injuries on streets, reflecting a drop from the average of 165 during the 2016–2019 period to 137 in 2020.

Source: Sarah Abel n.d.

Figure 1. Image. The city has implemented new projects in the downtown core, such as a separated bike lane on South Washington Avenue.

The Safe System Approach Highlights

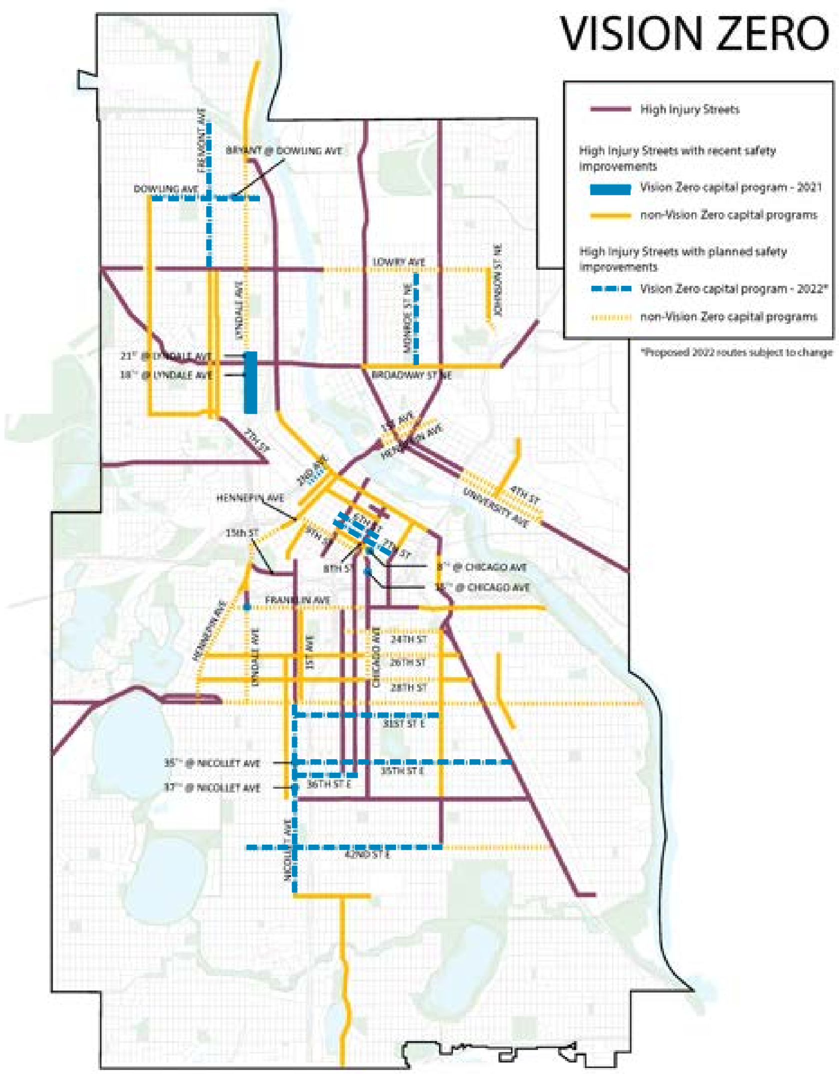
Death/serious injury is unaccepted: The city of Minneapolis has identified high-injury streets, which consist of only 9 percent of Minneapolis's streets but represent 70 percent of the city's severe and fatal crash locations between 2007 and 2016.[2]

Humans are vulnerable: The city has recognized that Native American and Black residents are disproportionately impacted by traffic deaths. For example, Black residents are 19 percent of Minneapolis population, but are 26 percent of people killed in traffic crashes.[3] Minneapolis has placed a strong emphasis on incorporating equity in its safety improvements, especially its urban core, which contains underserved communities that rely on safe, consistent multimodal transportation options.

Safety is proactive: The city has set proactive goals surrounding the safety of all road users with an emphasis on the fact that proactive changes need to be made. The city has created an interactive online map where community members can report traffic safety concerns along high injury streets. Community feedback will be used with crash data to help inform quick-build safety improvements.[4]

Background

After seeing the highest number of deaths and injuries on their streets since 2007 in both 2016 and 2017, the Minneapolis city Council adopted a Vision Zero resolution with the commitment to the goal of zero traffic deaths or serious injuries by 2027. To solidify the city's commitment to Vision Zero, the 2020–2022 Vision Zero Action Plan was released, setting the framework and strategy for the near future.[5] With guiding principles pushing for equitable, accountable, data-driven strategies that put safety and human lives first, the Vision Zero Action Plan is a core document in Minneapolis' implementation of the Safe System Approach. In 2020, the city of Minneapolis adopted the Minneapolis Transportation Action Plan which is shaped by Minneapolis 2040, the city's Climate Action Plan, Complete Streets, and Vision Zero policies.[6, 7, 8, 9] The goals in the transportation action plan are consistent with those of the other plans, allowing for a Safe System Approach to improving multimodal transportation conditions across Minneapolis. To combine the goals of the Transportation Action Plan and other efforts, the city released its *3.0 Street Design Guidance* in the spring of 2021, providing preventative design information based on these pre-established goals.[10]



Source: City of Minneapolis n.d.

Figure 2. Map. High injury network and project prioritizations map.

Implementation

The city of Minneapolis uses a variety of implementation strategies when applying the Safe System Approach in its urban core. Through a combination of preventative engineering, data-driven decision-making, and policy efforts, Minneapolis has an effective, systemic approach to showcase.

The city's Vision Zero Program is a key part of its application of the Safe System Approach as it employs an equity- and data-driven approach to reaching the goal of zero traffic fatalities and serious injuries.(11) As detailed in the Vision Zero Action Plan, a high percentage of traffic fatalities and injuries occur within the city's urban core, and 36 percent of all crashes occurred in Areas of Concentrated Poverty (ACP). Due to these alarming statistics, Minneapolis is dedicating more of its Vision Zero resources to these urban areas and tracking implementation in ACP areas as a key performance metric. To remain proactive in its decision making and hold itself accountable to its goal of zero, Minneapolis committed to issuing an annual Vision Zero report and progress reports every 6 months. Some of the metrics that focus on the urban core include the percentage of new safety treatments in ACP areas, the percentage of streets with high-injury rates receiving new safety treatments, the percentage change in traffic stops that involve people of color, and more.(12)

Minneapolis uses this data-driven process to target infrastructure improvements at key locations for annual Vision Zero safety improvement projects. These projects are typically quick-build safety treatments at spot locations along the high-injury network. The city's goal is to improve 46 miles of streets using spot treatments along with treatments on the high-injury network over the next few years. These safety improvements include curb extensions, pedestrian-crossing medians, lane narrowing, high-visibility crosswalk markings, bike conflict-zone markings, and changes to signal intervals. The city is allocating $3 million over the next 6 years in its Vision Zero program to implement these treatments.(13)

A project underway that is an example of Minneapolis' implementation of the Safe System Approach is the Hennepin Avenue project. The project is approximately 1 mile long and focuses on improving traffic safety and modal options in a neighborhood with racial disparities. Hennepin Avenue is highly trafficked by all modes of travel, and it runs directly through Minneapolis' urban center. The corridor is identified in the high-injury network, and in a 3-year crash study, it was found that pedestrians and bicyclists comprise 57 percent of injury crashes.(14) The project is currently under construction and will include a redesign to accommodate all travel types within the existing right of way. The completed project will have a sidewalk area with space for plants and furniture for pedestrians, one-way separated bikeways installed behind the curb, space for enhanced transit stops for the future BRT service, and four vehicle lanes for two-way travel.(15)

Using the information found in the Transportation Action Plan, Complete Streets Policy, Vision Zero Action Plan, and the Street Design Guide, the project is going to improve the experience of pedestrians, transit users, and bicyclists through increased safety and connectivity and improved infrastructure. By using in-depth data to drive these decisions, Minneapolis can ensure that it is improving conditions for marginalized communities that are disproportionally being impacted by road-safety issues.

Outcomes

Although the implementation of the Vision Zero strategies is recently developed and still underway, the city of Minneapolis has begun tracking key outcomes from the program. In 2020, the city installed quick-build safety improvements at 29 intersections, of which approximately 60 percent were located along streets in the high-injury network and in ACP areas. The city also completed more than 100 curb extensions and 12 pedestrian-refuge islands. Additionally, the city lowered speed limits on all streets in its jurisdiction, reducing speeds to 20 mph for residential streets, 25 mph for most collectors and arterials, and as low as 30 mph for a few arterials for a few arterials.(16)

Source: City of Minneapolis n.d.

Figure 3. Illustrative rendering for Hennepin Avenue redesign showing separated, behind-the-curb bike lane, widened sidewalk and transit stop.

From 2016 to 2020, there was a 26-percent decrease in the number of annual severe injury and fatal crashes in Minneapolis, reflecting a drop from 185 to 137. Similarly, there was a 46-percent decrease in severe injury and fatal crashes involving pedestrians over the same period. It should be noted, however, that 2020 saw 15 fatal crashes, a 30-percent increase over the average during the 2016–2019 period and the highest number of fatalities since 2013.(17)

Additional Information

For additional information, please contact Ethan Fawley, Vision Zero Program Coordinator with the city of Minneapolis at ethan.fawley@minneapolismn.gov or visit https://sdg.minneapolismn.gov/ and https://www.minneapolismn.gov/government/programs-initiatives/visionzero/ to learn more about the Street Design Guide and Vision Zero program.

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Washington State Collaboration with Local Jurisdictions – Washington State, USA

Key Successes

The safety coalitions in State of Washington have a firm commitment to implement Safe System Approach elements in the urban core. The strong collaboration between State and local agencies, traffic safety advocates, partners, and stakeholders resulted in safety improvements, such as the successes below:[1]

- A 13- to 18-percent reduction in injury crashes after speed limit reduction to 20 mph in Urban Villages in Seattle
- A 48-percent reduction in pedestrian turning collisions and a 34-percent reduction in serious injury and fatal pedestrian collisions after installation of leading pedestrian intervals (LPIs) in Seattle. LPIs are one of FHWA's Proven Safety Countermeasures, and transportation agencies should refer to the MUTCD for guidance on LPI timing and ensure that pedestrian signals are accessible for all road users. [2, 3]
- Development of an innovative, proactive network screening approach in Bellevue
- A 42 percent reduction in vehicle-pedestrian conflicts after LPI changes were made in Bellevue

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** The State adopted Target Zero as part of its Strategic Highway Safety Plan in 2019.
- **Humans make mistakes/humans are vulnerable:** The Washington State Department of Transportation's (WSDOT) approach to considering pedestrian and bicyclist activity when determining speed limits on urban and suburban roads reflects this concept. Seattle and Bellevue's speed reduction and LPIs improve vulnerable road user safety.
- **Responsibility is shared:** Washington State has a long history of traffic safety leaders who bring together key State and local agencies, traffic safety advocates, partners, and stakeholders to collaborate across organizational boundaries.
- **Safety is proactive:** Seattle takes a proactive approach to applying systemic speed limit reductions and signal timing changes; this approach is also reflected in its bike and pedestrian safety analysis processes. Bellevue's proactive network screening approach is based on surrogate safety measures.

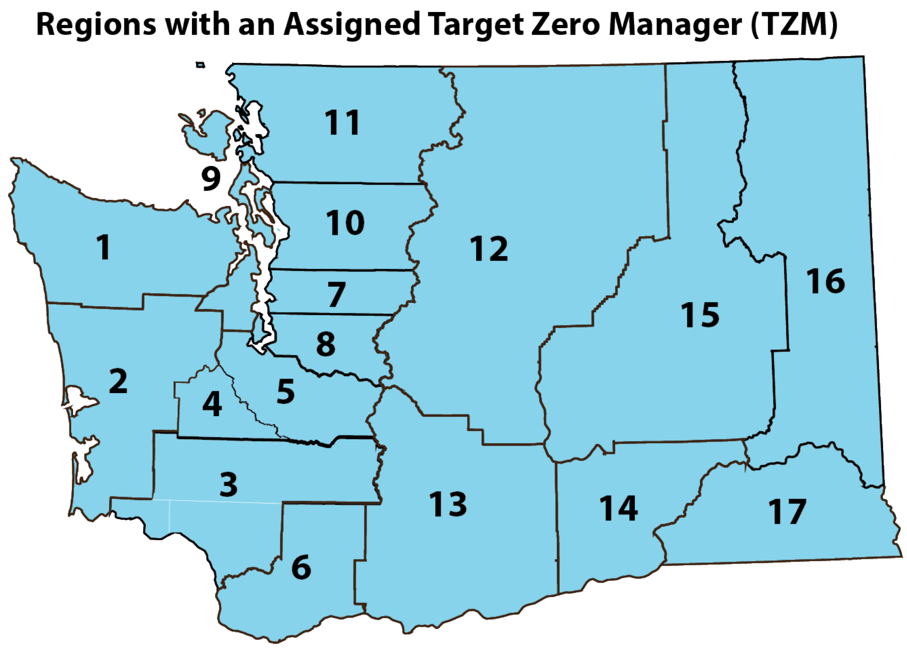
Background

In 2019, Washington State adopted Target Zero,[4] the Strategic Highway Safety Plan (SHSP) for the State. The plan's vision is to eliminate deaths and serious injuries on Washington's roadways by 2030. In addition to adopting Target Zero, WSDOT has developed numerous efforts to improve safety in the State even before the commitment to Vision Zero.[5, 6 ,7, 8, 9, 10, 11, 12] WSDOT also considers pedestrian and bicyclist activity when determining the speed limit on most urban and suburban streets. The combination of the State's commitment to improving safety and the strong collaboration between State and local agencies resulted in a noteworthy practice for implementing projects at a local level with State guidance.

Implementation

Approximately two-thirds of traffic fatalities and serious injuries in Washington occur on local roadways. Washington's progress toward Target Zero relies on the critical work being done by local agencies and traffic safety stakeholders. Target Zero analysts update community-specific crash data regularly on the WSDOT Crash Portal.(13) This data helps local agencies prioritize their traffic safety projects and programs and assists in developing localized Target Zero plans.

Washington State funds and supports Target Zero Managers (TZMs), who build regional coalitions of partners to implement solutions to local traffic safety issues. TZMs, as shown in Figure 1, guide local task forces within many counties as well as the State's Tribal reservations. These task forces are ideally composed of individuals with competencies in the 4E's—engineering, enforcement, education, and EMS—as well as other community agencies and organizations with an interest in traffic safety. The TZMs and task forces coordinate local traffic safety efforts and resources by tracking data, trends, and issues in their area. They develop and provide a variety of traffic safety programs, services, and public outreach throughout their communities by working with local partners.



Source: WSDOT n.d.

Figure 1. Map. Regions with assigned Target Zero Managers (TZMs) in Washington.

Target Zero includes key actions that a State or local jurisdiction can take to influence traffic safety. The plan adopts the Safe System Approach in its policies, programs, projects, activities, and investments. As part of Target Zero, WSDOT identified examples of Safe System strategies for addressing fatalities and serious injuries in the State, as summarized in Table 1.

Table 1. WSDOT Target Zero strategies for addressing safe systems fatalities and serious injuries.

Objective	Strategies	Implementation Areas
Apply the Safe System Approach to prioritize proven countermeasures	Complete infrastructure connectivity for pedestrians and bicyclists and make progress toward providing separation where needed based on crash exposure, crash history, and characteristics of the roadway and adjacent land use associated with higher levels of use.	Engineering
	Develop and implement speed management policy, guidelines, and professional training focused on injury minimization.	Education, Leadership
Address equity	Conduct demographic analysis to identify communities of concern.	Evaluation
	Increase investment in infrastructure in historically underserved areas where crash rates and severity are disproportionate to local and regional rates.	Engineering, Evaluation
	Support and report on development of city and county road safety plans based in principles of systematic safety	Evaluation, Leadership
Improve data and analysis	Develop and disseminate systematic safety data analyses by jurisdiction to provide context for crash rates, severity, contributing factors, and proven countermeasures	Evaluation

Source: WSDOT 2019.

Outcomes

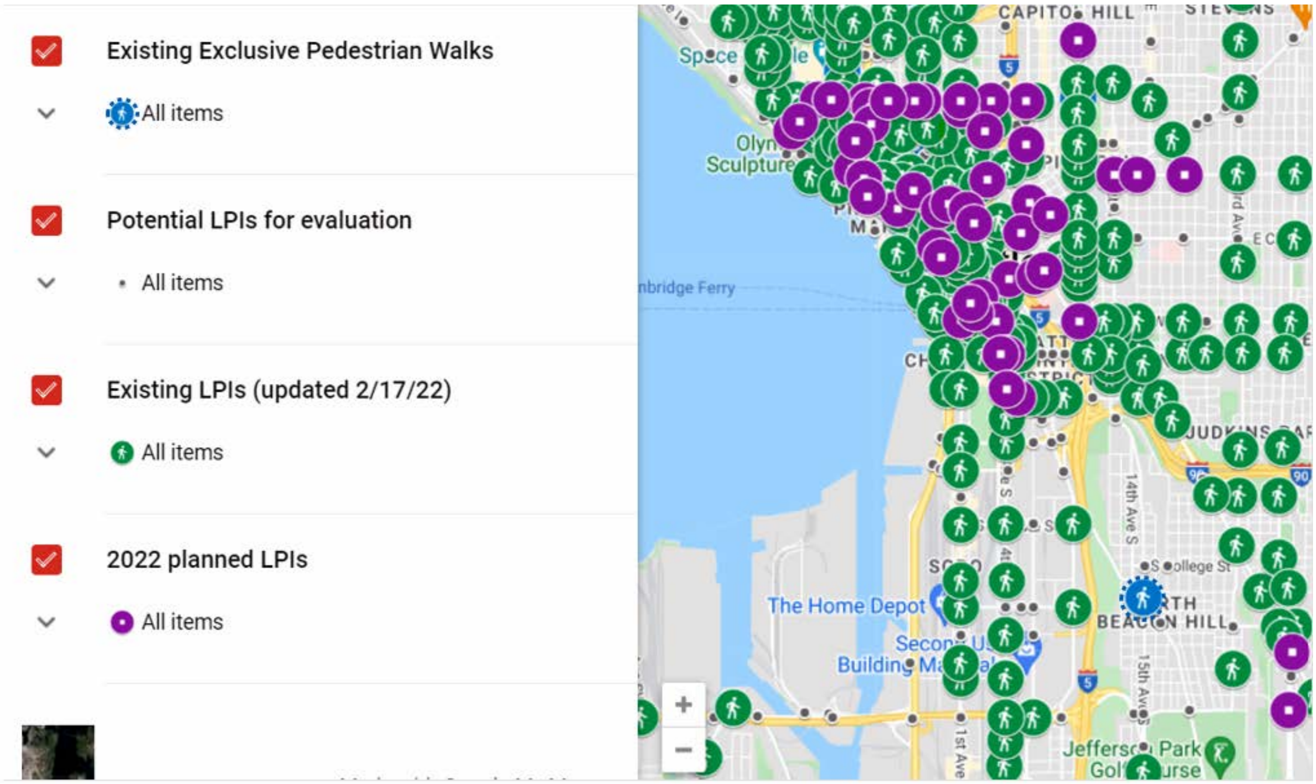
As a result of the strong collaboration between State and local jurisdictions, Target Zero goals have been successfully implemented in the urban core throughout Washington State. For example, noteworthy safety outcomes resulted from the engagement of TZMs and the cities of Seattle and Bellevue.

Seattle

TZMs in King County have been part of the Seattle Vision Zero initiative. Seattle adopted Vision Zero, with an emphasis on the Safe System Approach, in 2015. A few highlights from Seattle's Vision Zero efforts are shown below:[14]

- In 2016, the Seattle Department of Transportation (SDOT) reduced the speed limit on all 2,400 miles of its non-arterial streets to 20 mph and reduced the speed limit on 75 miles of city-center arterial streets to 25 mph. Since then, this program shifted focus to the city's Urban Villages (urban core), where 80 percent of pedestrian crashes occur. Early safety evaluation shows a 13 percent reduction in injury crashes on the Green Lake/Roosevelt Urban Village and an 18 percent reduction in injury crashes on the U-District Urban Center (from December 2018 to November 2019).[15]
- Since 2009, LPIs have been installed in Seattle at almost 450 intersections, which resulted in a 48 percent reduction in pedestrian-turning collisions and a 34-percent reduction in serious injury and fatal pedestrian collisions from 2009 to 2018.[16] In 2022, 70 additional LPI locations funded by WSDOT safety grants were planned. In 2019, a policy for installing leading pedestrian intervals (LPIs) every time a new traffic signal is built or an existing signal is maintained was adopted.[17] Seattle maintains a map, as shown in Figure 2, showing LPI existing and proposed locations.[15]

- SDOT undertakes regular Bike and Pedestrian Safety Analyses to understand what roadway conditions are contributing to higher crash risk and where SDOT should focus efforts to proactively improve safety for pedestrians and bicyclists.[18]
- Seattle's Vision Zero Team meets regularly with the local King County TZMs to review recent crashes, data, and enforcement efforts.



Source: WSDOT n.d.(b)

Figure 2. Map. Example of area showing LPI locations in Seattle.

Bellevue

TZMs in King County have also been part of the Bellevue Vision Zero initiatives. In coordination with TZMs in 2020, Bellevue adopted a Vision Zero plan with a focus on the Safe System Approach to eliminating traffic deaths and serious injury crashes on city streets by the year 2030.[19] A few elements from Bellevue's Vision Zero plan include the following:

- Implementation of rapid build road safety projects along five high-injury networks (HIN) corridors. Countermeasures include radar feedback signs, pedestrian crossings, and medians.
- Periodically conducting Road Safety Assessments (RSAs) in partnership with WSDOT and FHWA.
- Lowering the speed limits for all streets in the Surrey Downs neighborhood of Bellevue from 25 mph to 20 mph.[20]
- Maintaining a Bellevue Collision Dashboard to better understand the collisions that have occurred on city streets this past decade.[21]

- A video analytics systematic project uses Bellevue's system of 360-degree, high-definition traffic cameras to identify near-crash traffic conflicts between people driving, walking, and bicycling.(22) LPIs were installed at 20 intersections in the Downtown and Crossroads areas with traffic cameras that were used to observe more than 650,000 road users. There was a 42 percent reduction in vehicle-pedestrian conflicts after LPI changes were made.(23) Using a sample of 40 cameras and intersections in Bellevue, a proactive network screening approach was developed based on surrogate safety measures.(24) This proactive tool can constantly look for high risk locations and risk contributing factors, and potential safety improvements are proposed even before crashes occur.

Additional Information

Collaboration between State and local agencies, traffic safety advocates, partners, and stakeholders is a strong characteristic in Washington State. Established in 1967, the Washington Traffic Safety Commission (WTSC) has allowed agencies and organizations to share traffic safety responsibility. In March 2022, Washington State Governor Jay Inslee signed into State law ESSB 5974, a complete streets/safety provision for new projects.(25) This law addresses accessibility, sidewalks, and bicycle facilities in population centers and became effective as of July 1, 2023, for all new projects in the design phase valued at more than $500,000. For more information regarding WSDOT safety efforts and collaboration with local jurisdictions, contact John Milton, State Safety Engineer, at miltonj@wsdot.wa.gov.

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European Union Case Studies

Key Successes

Through strategies such as traffic calming, creation of lower speed zones, lighting of pedestrian crossings, improvement of roadway accessibility, construction of raised crosswalks, dedicated bicycle facilities, prioritization of high-crash locations, and post-crash response, the number of road deaths in Europe dropped by 36 percent from 2010 to 2020.[(1)] A few key successes from European urban areas include the following:

- **Torrejon de Ardoz, Spain:** The city has experienced zero road fatalities for 12 years straight.[(2)]
- **Gothenburg, Sweden:** It is estimated that four out of five injuries sustained on the city's roads do not involve a car occupant. Single bicycle or single pedestrian injuries account for 80 percent of all serious or moderate injuries sustained.[(3)]
- **Malopolska, Poland:** The city's pilot program, which includes systemic illumination of pedestrian crossings, reduction of speed limits before all pedestrian crossings, prevention programs aimed at pedestrians, and post-crash response psychological help for victims and families of victims, was adopted in the entire country in 2021.[(4)]
- **Czech Republic:** The estimated annual average decrease in the number of deaths on urban roads from 2010–2017 was 5.5 percent. The proportion of drivers going above the speed limit in urban areas by more than 10 km/h (6 mph) decreased from 9 percent in 2014 to 6 percent in 2018.[(5)]

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** The European Union (EU) has the ultimate goal of eliminating traffic deaths and serious injuries by 2050.
- **Humans make mistakes/humans are vulnerable:** The EU has instituted a number of countermeasures to alleviate human error and vulnerability, including vehicle safety requirements; modal priority for road users, the hierarchy being based on safety, vulnerability, and sustainability (with walking as the top priority); creation of lower speed zones; pedestrian and bicyclist improvements (lighting of pedestrian crossings, raised crosswalks, dedicated bicycle facilities, etc.); traffic calming to reduce speeds; post-care response efforts.
- **Responsibility is shared:** The EU works closely on road safety with the authorities in its member countries by adopting laws, providing funding, supporting public education campaigns, and helping member countries and other road safety actors share relevant experience.
- **Safety is proactive:** The EU installs systemic improvements including roundabout construction, raised crosswalks, pedestrian lighting, improvement of roadway accessibility.
- **Redundancy is crucial:** The EU focuses on engineering countermeasures, lighting of pedestrian crossings, educational safety programs, enforcement, and post-crash response improvements.

Background

Cities and towns account for 72 percent of the population of the EU.(6) In 2010, the EU committed to reducing road deaths by 50 percent compared to 2010 levels by 2020.(7) With the ultimate goal of eliminating road deaths and serious injuries by 2050, the European Commission has put together a Road Safety Policy Framework 2021-2030 to set intermediate targets to halve the number of fatalities and serious injuries on European roads by 2030. The EU has adopted the Vision Zero and Safe System Approach to eliminate deaths and serious injuries on European roads.(8)

The European Union works closely on road safety with the authorities in its member countries. It seeks to build on national initiatives, setting targets and addressing crash contributing factors. The EU adopts laws, provides funding, supports public education campaigns, and helps member countries and other road safety actors share relevant experience.

The European Transport Safety Council (ETSC) published a report in 2019 with a focus on urban road safety in the EU. The report showed that, in urban centers, 70 percent of reported road deaths involved pedestrians, cyclists, and power-two-wheeler (PTW) riders.(9) Further, 35 to 75 percent of observed vehicle speeds in free-flowing traffic in urban areas were higher than the legal speed limit. The report's main recommendations for cities and towns included the following:(10)

- Adopt a local road safety strategy based on the Safe System Approach, set road safety targets, and dedicate an appropriate budget.
- Include road safety as an essential component in developing and implementing Sustainable Urban Mobility Plans (SUMPs).
- Adopt and promote a policy of modal priority for road users, the hierarchy being based on safety, vulnerability, and sustainability. Walking should be at the top of the hierarchy, followed by cycling and use of public transport.
- Establish clear urban road hierarchies which better match road function to speed limit, layout, and design based on the principles of the Safe System Approach.
- Adopt 30 km/h (19 mph) zones supported by traffic calming measures in residential areas, areas used by many pedestrians, and cyclists and on the way to schools.
- Introduce vehicle safety requirements, such as direct vision, Intelligent Speed Assistance, Automated Emergency Braking with pedestrian and cyclist detection, and alcohol interlocks in public procurement requirements for city services (e.g. waste trucks, public transport buses).

Implementation and Outcomes

The Netherlands was one of the first nations to develop and implement the Safe System Approach. Examples of projects implemented over the years by the Netherlands include reducing the speed limit of city access roads to 30 km/h (19 mph) and main roads to 50 km/h (31 mph), with separated bicycle lanes and other interventions to avoid crashes between motorized traffic and bicycles. The operational design criteria and determination of speed limits in the Netherlands occur after a categorization of the road, which involves examination of the road network to determine the road functional classification (flow versus access). In the urban core, high speed roads are enforced with cameras, whereas low speed roads are enforced by design (with traffic calming measures such as speed humps).(11)

Following the EU commitment to reduce road deaths by 50 percent by 2020, several countries, cities, and towns adopted the 2011-2020 EU road safety program. From 2010 to 2020, the number of road deaths in Europe dropped by 36 percent.[12] A few noteworthy practices that incorporated elements from the Safe System Approach to improve safety in the urban core are described below:

2021 EU Vision Zero Municipal Award Winner: Torrejon de Ardoz, Spain

Torrejon de Ardoz is a municipality of approximately 130,000 residents in the Community of Madrid, Spain. For the last decade, city officials have focused on promoting Torrejon as a safe and enjoyable place rather than just a place to sleep. Traffic safety has been the city's priority since 2007.[13]

Torrejon has a Pedestrian Safety Plan (Plan Seguridad Viandantes) and an Accessibility Plan (Plan de Eliminación de Barreras Arquitectónica).[14, 15] The city's strategies to improve safety include the following:[16]

- Systemic replacement of traffic signals with roundabouts: The roundabouts are flat, without raised centers, plants, or fountains, which is cost-effective. Barriers separate the sidewalk from the road to inhibit pedestrians from taking a shortcut across the roundabout.
- Systemic lighting improvements of pedestrian crossings: This effort has been implemented citywide to increase pedestrian visibility.
- Prioritization of pedestrian crossings: Construction of raised crosswalks at hundreds of locations based on citizen feedback.
- Dedicated bicycle facilities: The "Anillo Ciclista" includes 13.4 km (8.3 mi) of separated bicycle facilities that connects hospitals, train stations, parks, recreational facilities, and cultural centers.
- Prioritization of hotspots: city police identifies high-crash locations, which are made top priority when defining safety measures.
- Bicycle parking: Free-of-charge bicycle parking facilities at railway stations to encourage cycling and transit use rather than automobile use.
- Community participation: The city administration involves residents in its planning consultations. Also, because the city's future will be in the hands of its children, road safety education is provided at schools from an early age. The education program is completed by 5,500 children each year.

Torrejon de Ardoz has experienced zero road fatalities for 12 years in a row. The city was the recipient of the 2021 EU Vision Zero Municipal Award Winner.[17] The city has adopted a Sustainable Mobility Plan for 2021 to 2030 that focuses on vulnerable road user safety.[18]

Gothenburg, Sweden

With the implementation of traffic calming and separation of vulnerable road users from motorized traffic, motor vehicle traffic shifted from local city roads to arterial or national roads, which is where possible conflicts with pedestrians or cyclists are less frequent. Lower speeds and reductions in motorized traffic encouraged citizens to walk and cycle more often. It is estimated that four out of five injuries sustained on the city's roads do not involve a car. Single bicycle or single pedestrian injuries account for 80 percent of all serious or moderate injuries sustained.[19]

Malopolska, Poland

In 2018, approximately 70 percent of pedestrian crashes in Malopolska, Poland, occurred around pedestrian crossings. Improvements included a systemic illumination of pedestrian crossings, reduction of speed limits before all pedestrian crossings, prevention programs, and post-crash response psychological help for victims and families of victims. In 2021, the Polish government applied the Malopolska program to the entire country, with a separate budget for county roads and municipal roads. Also in 2021, Poland introduced a set of legal changes in the country's Traffic Code referring to pedestrian safety (including priority of pedestrians approaching pedestrian crossings and a ban on phone use while crossing the road), maximum speed limit of 50 km/h (31 mph) in the urban core, regulations regarding e-scooters and safe distance between vehicles, as well as very strict penalties in the Penal Code for any offenses and crime on roads.(20)

Additional Information

In addition to these efforts, a few examples of national implementation of safety countermeasures are applicable to the urban core. Czech Republic implementation of traffic calming measures, upgrades of pavements, building of cycling infrastructure, illumination of pedestrian crossings, speed enforcement by safety cameras, and police roadside checks resulted in an estimated annual average decrease in the number of deaths on urban roads from 2010-2017 of 5.5 percent. Further, the proportion of drivers going above the speed limit in urban areas by more than 10 km/h (6 mph) decreased from 9 percent in 2014 to 6 percent in 2018.(21) In Georgia, the creation of a single crash response number and the establishment of a Public Safety Command Center have increased the capacity to contact emergency assistance, increased accessibility for people with disabilities, improved the geo-location of incidents, and reduced dispatch times.(22) In Moldova, the adoption of a single crash response and dispatch number, enforcement projects, road infrastructure projects, and road safety education programs contributed to a 44-percent decrease in crashes from 2010-2021. The post-crash response program in Moldova contributed to reductions in incident response times from an average of 60 minutes in 2009 to less than 15 minutes in 2018.(23)

The EU Road Safety Policy Framework 2021-2030 states that EU funding is an important lever to prepare future road safety solutions and accelerate the delivery of road safety results. A few funding options described in the policy include the European Regional Development Fund (ERDF), Cohesion Fund, Connecting Europe Facility (CEF), and the "Safer Transport Platform" (a one-stop-shop for road safety investment under the support of the European Investment Advisory Hub (EIAH). For more information, contact Antonio Avenoso, ETSC Executive Director, at antonio.avenoso@etsc.eu or Veronique Feypell, International Transport Forum (ITF) Research Centre Administrator, at veronique.feypell@itf-oecd.org.

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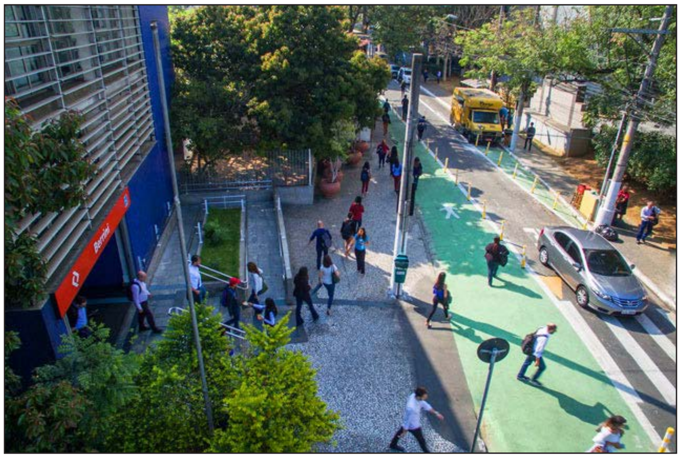
South America Case Studies

Key Successes

Case studies in South America showed that safety concerns were mostly related to speeding and vulnerable road users in the urban core. A few success stories from the cities of Bogotá, Colombia; São Paulo, Brazil; and Salvador, Brazil are summarized below:

- **Bogotá:** The city's speed management program resulted in approximately 11 percent reduction in road fatalities.[(1)]
- **São Paulo:** Improvements in road design, as shown in Figure 1, signage, and pedestrian crossing times resulted in a 68 percent reduction in fatalities in one year at the M'Boi Mirim Corridor.[(2)]
- **Salvador:** Infrastructure modifications on arterial roads and speed limit enforcement technologies resulted in a 54-percent decrease in fatal traffic crashes.[(3)]



Source: Joana Oliveira/WRI Brasil 2019.

Figure 1. Image. Renovated and widened sidewalks at Joel Carlos Borges Street in São Paulo.

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** The city committed to Vision Zero plans.
- **Humans make mistakes/humans are vulnerable:** Planned improvements included reduction of maximum road posted speeds, speed limit enforcement technologies, pedestrian and bicyclist infrastructure redesign, traffic calming measures, dedicated bus lane networks for road user separation in space.
- **Responsibility is shared:** The city focused on development of road safety plans that involved the community, public agencies, and stakeholders. Plans used a combination of engineering, driver education, and enforcement measures to reduce speeds.
- **Safety is proactive:** Enhancements focused on systemic reduction of speed limits and systemic traffic signal system improvements.
- **Redundancy is crucial:** The city's speed management program included engineering, education, and enforcement efforts to lower speeds. It also used mass media campaigns and trained journalists to help educate citizens on road safety.

Bogotá, Colombia

Background

The city of Bogotá, which has a population of almost 7.5 million, is the capital of Colombia and one of the largest cities in the world. Bogotá launched its Vision Zero Road Safety Plan in 2017 and its main element is a speed management program (SMP).[4, 5] The Vision Zero Road Safety Plan identified speed as one of the main road safety issues to be addressed in Bogotá. In 2016, vulnerable road users accounted for 96 percent of all fatality victims and 72 percent of all fatalities occurred on arterial roads.[6]

Implementation

The SMP comprises more than lowering speed limits and includes efforts in engineering, education, and enforcement. The SMP began implementation by lowering the speed limit from 60km/h (37 mph) to 50km/h (31 mph) on five arterial corridors, which presented the highest rates of road traffic victims and fatalities. These pilot programs and temporary interventions were used to test and improve methodologies and actions. After the five initial corridors, another five were added to the program. The strategies applied in the corridors were mostly posting speed limit signs complemented with speed cameras and police enforcement and accompanied by a communication strategy. The 50 km/h (31 mph) speed limit has since been expanded across the city as the maximum speed limit on most arterial roads.[7]

The speed management program also introduced low-speed zones in residential neighborhoods, around schools, and in commercial areas. More than 2,000 school zones and other local streets have new infrastructure and signs stating a maximum speed of 30 km/h (19 mph). Other infrastructure design changes, such as fewer travel lanes, smaller turning radii, and speed bumps, force drivers to travel at lower speeds.

Outcomes

In the first seven months of 2019, the number of deaths reported in Bogotá was the lowest in a decade. Road deaths dropped 11 percent compared to the same period in 2018 and 2019, and 12 percent compared to the average number of fatalities between 2014 and 2018. From 2018 to 2019, the largest reductions were in motorcyclist (28 percent) and pedestrian (17 percent) fatalities.[8]

In the first half of 2020 there was a 33 percent reduction in fatalities compared to the first semester of 2019, and in the first 14 months after implementation (October 2018-December 2019), 46 lives were estimated to have been saved. From May to December 2020, there was a reduction of 56 fatalities compared to the same period 2017-2019 average. Since the plan was executed, the city has saved US $12.6 million in cost represented in property damages, medical, administrative, and human costs.[9]

São Paulo, Brazil

Background

With a population of almost 12.5 million (eighth largest in the world), the city of São Paulo works towards making its streets safe for all road users. In April 2019, São Paulo became the first Brazilian city to establish a road safety plan based on the Safe System Approach. The plan, known as Vida Segura (Safe Life), set a goal of reducing the traffic fatality rate by more than half in 10 years, to 3 deaths per 100,000 people. The plan is the result of one year of work, with the involvement of 200 people, 15 public agencies, and more than 50 contributors to prepare the final text. It was also supported by the Bloomberg Initiative for Global Road Safety.[10]

Implementation

Vida Segura rests on four crucial aspects:

- **Using open data to drive solutions:** Data is vital to diagnosing and designing evidence-based interventions. Vida Segura establishes an open digital platform that contains data from radar equipment available to the public.
- **Redesigning streets for the most vulnerable:** São Paulo is beginning its infrastructure redesign by targeting the high-risk corridors in the city. Plans include low-speed zones as shown in Figure 2, safe school routes, renovated and widened sidewalks, expanded cycle infrastructure, improved signage, increased crossing times, and increased enforcement.

Source: Joana Oliveira/WRI Brasil 2019.

Figure 2. Image. Low-speed zone at the Santana neighborhood in São Paulo.

- **Reclassifying roads to manage speeds:** In the Vida Segura Plan, São Paulo has committed to reviewing the classifications of its roads according to the Safe System Approach, which is prioritizing the safety of all users instead of just vehicles. In keeping with the World Health Organization's recommendation to limit maximum speeds to 50 kilometers per hour within the urban perimeter, the city plans to set that maximum speed limit for arterial roads, dropping it to 40 kilometers per hour for collector roads, and 30 kilometers per hour for local roads. High-speed roads that lack safe infrastructure for pedestrians and other non-vehicle users will be reclassified as arterials.
- **Building support and capacity:** city staff (decision makers, architects, planners) will also need to be trained to develop their activities according to the Safe System Approach and to help implement new measures such as road safety audits. While most Brazilian cities still lack capacity for road safety audits, São Paulo plans to use them to identify safety issues with existing projects and roadways and to provide recommendations for mitigating risks at key sites.

Outcomes

Implementation of São Paulo's Road Safety Plan near-term goals and actions were notably impacted by the COVID-19 pandemic. Therefore, information and data on outcomes and implementation are limited. São Paulo began its infrastructure redesign by targeting the high-risk corridors in the city. Plans included low-speed zones, safe school routes, renovated and widened sidewalks, expanded cycle infrastructure, improved signage, increased crossing times, and increased enforcement. These interventions have already been successfully deployed in the busy M'Boi Mirim Corridor, where improvements in road design, signage, crossing times and other areas resulted in a 68 percent reduction in fatalities in just one year.(11)

Salvador, Brazil

Background

With a population of almost three million, Salvador is the fourth largest city in Brazil. Since 2013, Salvador began implementing the Vida no Trânsito (Life in Transit) program, an initiative created by the Brazilian Ministry of Health in partnership with the Pan American Health Organization (PAHO). The program uses data analysis to guide decision-making and includes traffic calming measures, driver education, and greater enforcement of speeding and drunk driving laws. In 2020, Salvador joined the Bloomberg Initiative for Global Road Safety and is now targeting reducing motorcyclist deaths in the city. Of the total traffic deaths in 2020, 38 percent were motorcyclists. Cyclist and pedestrian safety also continue to be prioritized by the city.(12)

Implementation

The greatest obstacle the city faced to implementing the Life in Transit program was a lack of standardized data and integrated information system that made it difficult to diagnose the city's road safety problems. The program's first steps included collecting and analyzing data on traffic events and their contributing factors, which were then used to design evidence-based measures to prevent road traffic injuries and fatalities at hotspots. With this new data, Salvador began implementing infrastructure modifications on arterial roads, such as adding raised crosswalks, and installing speed limit enforcement technologies.(13) Salvador also undertook a widespread educational campaign for students. With the UN's Second Decade of Action, Salvador is expanding its work into motorcycle safety and low-speed zones through "Zonas 30." In the Bonfim neighborhood shown in Figure 3, the low-speed zone saw great results with a 77 percent reduction in vehicles exceeding the speed limit in the area and 91 percent overall compliance.()

Source: Global Design Cities Initiative 2020.

Figure 3. Image. Low-speed zone improvements in the Bonfim neighborhood in Salvador.

Outcomes

In 2010, Salvador recorded 266 fatal traffic crashes. By 2017, fatalities had dropped to 121, a decrease of 54 percent. The city then became one of the few to successfully meet the UN 2011-2020 Decade of Action for Road Safety goal. In 2020, Salvador recorded 126 traffic deaths, demonstrating that their efforts continue to achieve results. As of 2021, Salvador had a rate of 5.2 traffic deaths per 100,000 inhabitants, three times less than the national average.(14)

Additional Information

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ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE