



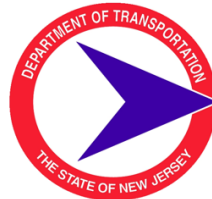
Source: NJBPRC

Addressing Fatal & Serious Injuries through the Safe System Approach

A Literature Review, Case Studies & Findings

RUTGERS

Edward J. Bloustein School
of Planning and Public Policy



December 2022

Acknowledgment

The **Alan M. Voorhees Transportation Center (VTC)** is a national leader in the research and development of innovative transportation policy. Located within the Edward J. Bloustein School of Planning and Public Policy at Rutgers University, VTC has the full array of resources from a major research university on transportation issues of regional and national significance.

The **New Jersey Bicycle and Pedestrian Resource Center (BPRC)** assists public officials, transportation and health professionals, and the public in creating a safer and more accessible walking and bicycling environment through primary research, education and dissemination of information about best practices in policy and design. The Center is supported by the New Jersey Department of Transportation through funds provided by the Federal Highway Administration.

Report Author

Monika Pal

Report Contributors

Leigh Ann Von Hagen, AICP, PP

James Sinclair

Gregory Woltman

Samuel Rosenthal, AICP

Alan M. Voorhees Transportation Center

Edward J. Bloustein School of Planning and Public Policy

Rutgers, The State University of New Jersey

33 Livingston Avenue, Fourth Floor

New Brunswick, New Jersey 08901



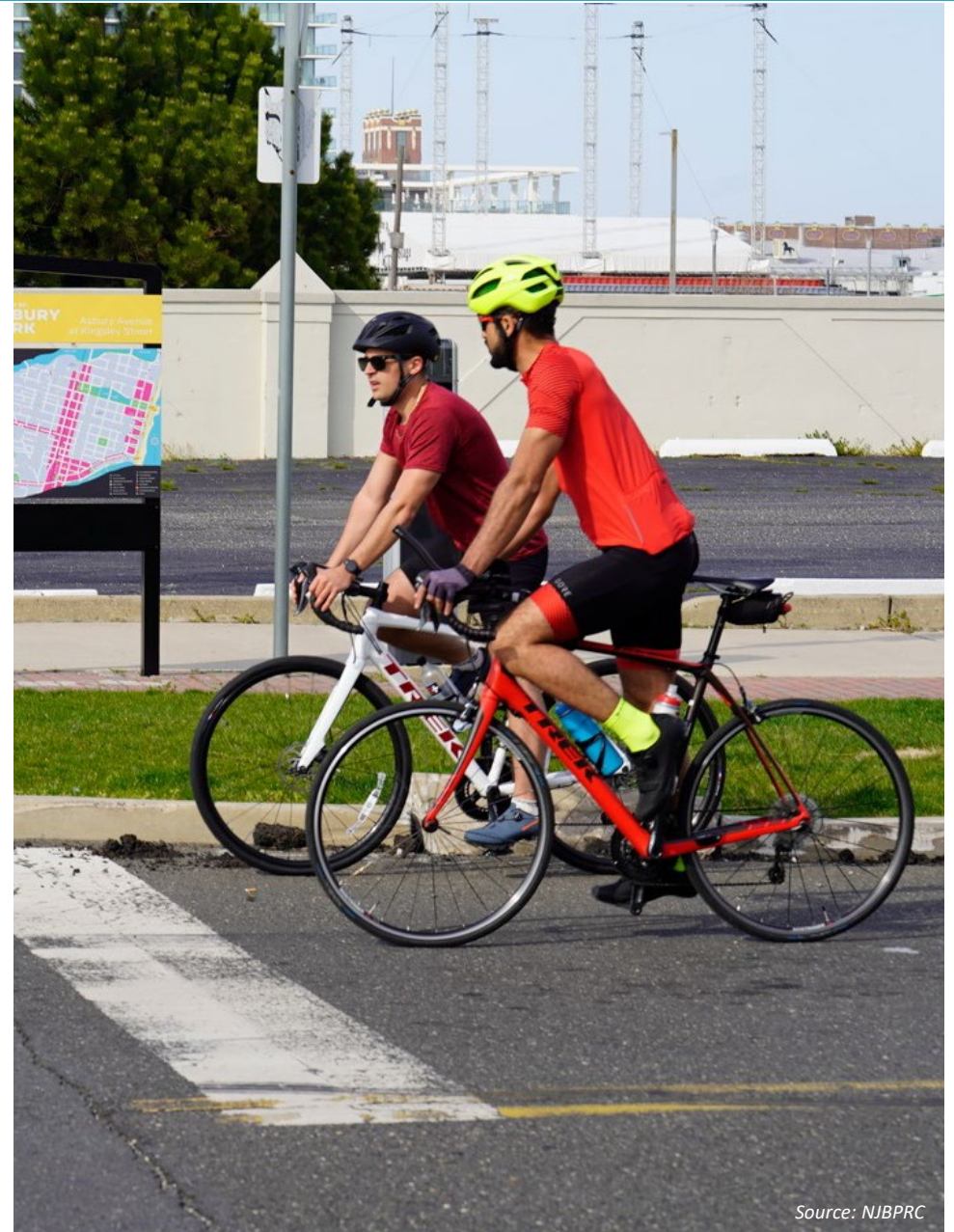
Executive Summary

The Safe System Approach is an internationally recognized and successful practice that sets an ethical imperative that it is unacceptable to allow fatal and serious injuries (FSI) to occur on public roads. The goal is to have zero fatal and serious injuries. Rather than focusing on changing human behavior and preventing all collisions, the Safe System Approach refocuses transportation system design and operation on anticipating human errors and reducing impact forces to minimize crash severity and save lives. The Safe System Approach takes into account the safety of all road users, but especially those who are most vulnerable to death or serious harm in the case of a collision, such as bicyclists and pedestrians.

The Safe System Approach is a global movement that has been in place for more than three decades. During the period 1994-2015, countries that implemented the strategy saw significant reductions in mortality, ranging from 50-60% in Australia, the Netherlands, and New Zealand to 60-70% in Sweden. All Safe System pioneer countries made significant efforts to involve, engage, and persuade all stakeholders whose contributions would be required to make a Safe System work.

The Safe System Approach is proven to be cost-effective, with benefits outweighing expenditures by three to four times. It requires strong and enduring leadership to instill a feeling of urgency for change, engage stakeholders successfully, and secure their support for the paradigm shift that prioritizes safety over speed.

This report examines how the Safe System Approach aims to reduce fatal and serious injuries in the USA and globally. The report provides an overview of the principles and elements of the Safe System Approach. Further, it discusses the national FSI trends and zero-death principles in Strategic Highway Safety Plans. Furthermore, the report sheds light on how this approach benefits pedestrians and bicyclists and ensures transportation equity across the system.



Source: NJBPRC

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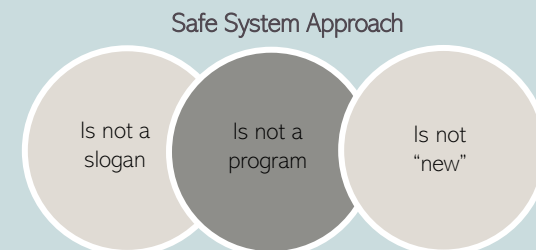
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Source: NJBPRC

I. Introduction

The Safe System Approach is a global movement that has been in place for more than three decades. In the USA, safety is the foremost priority for the Federal Highway Administration (FHWA). The FHWA firmly supports the goal of zero fatalities and serious injuries on the nation's highway system and acknowledges that a Safe System is the way to get there [11]. All road users will benefit from the Safe System approach, which strives to reduce fatal and serious injuries. It takes a holistic approach to the road system, first anticipating human errors and second keeping the impact energy on the human body at tolerable levels [2].



It is a paradigm shift in how we approach safe mobility.

Source: FHWA Safe Systems Webinar held on 06.10.2022

Vision Zero states that no one should be killed or badly wounded on the road system [11]. This notion spawned the Safe System Approach to road safety on a global scale. During the period 1994-2015, countries that implemented the strategy saw significant reductions in mortality, ranging from 50-60% in Australia, the Netherlands, and New Zealand to 60-70% in Sweden [FHWA Safe Systems Webinar conducted on 06.10.2022]. According to a World Resources Institute study of 53 nations, those which implemented the Safe System Approach witnessed a 50% decrease in mortality rates between 1994 and 2015 [9]. As a result, several countries and jurisdictions in the United States are implementing a Safe System approach on their highways. The method also serves as an equity tool in places that have been traditionally disregarded, underserved, and disproportionately exposed to traffic-related risks [17].

Rather than focusing on changing human behavior and preventing all collisions, the Safe System approach refocuses transportation system design and operation on anticipating human errors and reducing impact forces to minimize crash severity and save lives. [1].

Traditional Approach

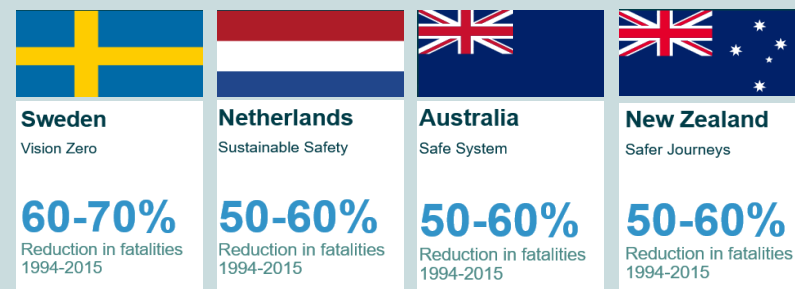
- Prevent crashes
- Improve human behavior
- Control speeding
- Individuals are responsible
- React based on crash history

Safe System Approach

- Prevent deaths and serious injuries
- Design for human mistakes/limitations
- Reduce system kinetic energy
- Share responsibility
- Proactively identify and address risks

Source: FHWA [1]

Successful Safe System Adopters



Source: FHWA Safe Systems Webinar conducted on 06.10.2022

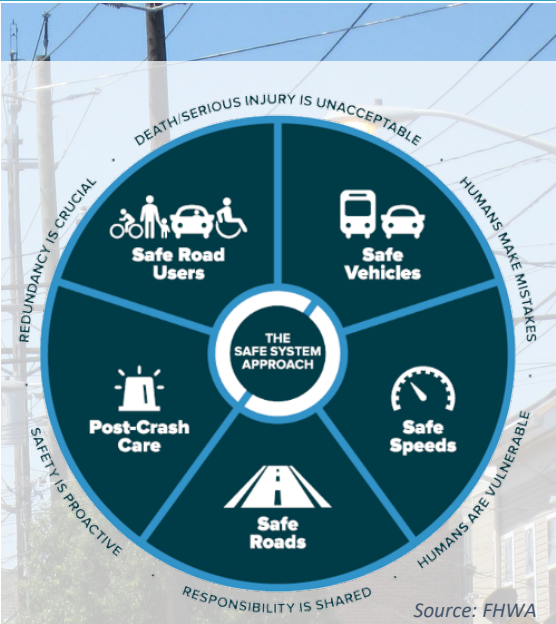
The concepts of a safe system approach may appear to indicate a different strategy than typical behavioral safety initiatives at first glance. They do, however, correspond with long-standing behavioral safety techniques in many respects. A culture in which any death or major harm is unacceptable is strengthened by an emphasis on these ideals. Professionals in behavioral safety understand that humans make mistakes and are susceptible, and they have created programs to address these issues [17]. The Safe System Approach has roots in a public health approach that uses data to identify patterns of injury and disease. The public health discipline's commitment to methods of research, evaluation and equity, and its population-level approach to analyzing traffic collisions, bring an important and necessary perspective to reach zero fatality goals [41].

II. Principles of Safe System Approach

The Safe System Approach is different from traditional safety practice because it puts the needs of people first. It fully integrates the needs of all users of the transportation system, including vulnerable road users like pedestrians, bicyclists, older, younger, disabled, etc. It seeks safety through a stricter use of roadway design and system changes rather than focusing exclusively on behavioral changes [21]. The Safe System approach is based on the six principles shown below [1]:

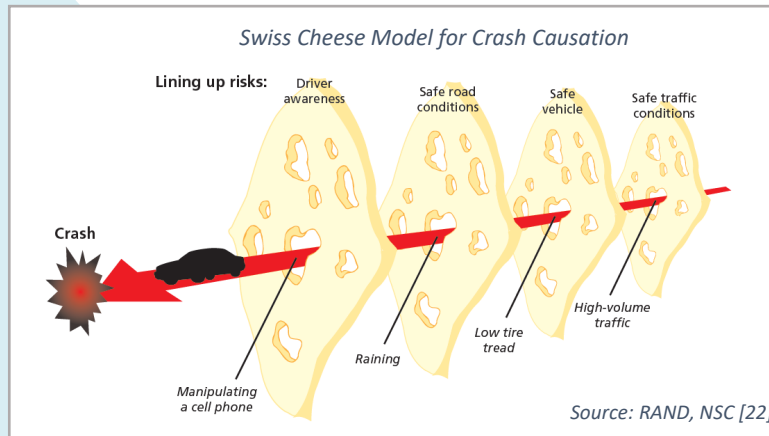


Source: FHWA [1]



III. Elements of Safe System Approach

The Safe System method integrates a wide range of interventions to address the five elements of a safe transportation system: safe road users, safe vehicles, safe speeds, safe roads, and post-crash care. All roads, including freeways, municipal roads, and rural roads, are subject to these five elements. According to the Safe System Approach, each of the five components must be strengthened in order to achieve zero traffic fatalities and serious injuries. Additional attention to one or more elements may compensate for weaknesses in another [3]. Just like a piece of Swiss cheese, a true systems approach involves optimization across all elements to create layers of safety against harm on the road [22].



The principles and elements of the Safe System Approach make it clear that the responsibility does not fall on road engineers and vehicle designers only. Behavioral interventions, such as education and enforcement, are also important in promoting more responsible road usage [17]. However, in too many situations, enforcing traffic laws harms people rather than keeping communities safe. Research bears out that the enforcement of traffic laws is racialized: Black people are stopped and cited disproportionately more often for traffic violations compared to white people, even if Black people comprise a smaller percentage of a community's population [42]. Moreover, it has been found that education campaigns are unlikely to work, especially when most of the audience already knows what to do. Therefore, highway safety messages conveyed in signs, pamphlets, brochures, on buttons, etc. are unlikely to have any effect on behavior [43]. Thus, roads can be designed so that the need for traffic law enforcement is reduced. Designers may adjust lane width, sight distances, and other roadway cues so that the speed at which drivers are comfortable is also at or below the speed limit. Pedestrian crossings and bike paths may be designed so walkers and cyclists find that the easiest way to get across traffic is the safe way. In a Safe System, roads are designed such that the intuitive behavior is the safe behavior. These designs save lives and reduce the need for traffic law enforcement to achieve safety [20].

Safe Road Users

The Safe System method accounts for the safety of all road users, including those who drive, walk, bike, take public transportation, and utilize other means of transportation.



Safe Vehicles

Vehicles are built and regulated to reduce the likelihood and severity of crashes by including cutting-edge safety features.



Safe Speeds

Humans are unlikely to survive high-speed collisions. Reduced speeds can accommodate human injury tolerances in three ways: collision forces are reduced, drivers have more time to stop, and visibility is improved.



Safe Roads

By designing roads to accommodate human errors, the severity of collisions that do occur may be considerably reduced.

Physically separating people going at various speeds, allowing different users to traverse through a place at different times are just a few examples.



Post-Crash Care

People who are injured in a crash depend upon the emergency first responders to stabilize their injuries and transport them to medical facilities as soon as possible.



Source: FHWA [11]

IV. Safe System Approach in the USA

The Highway Safety Act of 1970 reaffirmed the US government's commitment to ensuring the safety of the traveling public. The legislation established the National Highway Traffic Safety Administration (NHTSA) to minimize the number of deaths, injuries, and economic losses caused by motor vehicle collisions on the nation's roadways. NHTSA estimates that improved car safety technology has saved more than 600,000 lives since 1960 [7]. Unfortunately, automobile collisions continue to claim far too many lives of family members, friends, and neighbors in the United States [7]. For more than a decade, traffic deaths in the United States have hovered consistently between 32,000 to 39,000 each year [3]. Pedestrians made up 17% of traffic fatalities in 2019 with 6,205 fatalities whereas bicyclists accounted for approximately 2% of fatalities in 2019 with 846 bicyclist fatalities [8].



VISIONZERO



Vision Zero, Road to Zero, and Toward Zero Deaths are the three largest efforts in the USA that share the goal of eliminating fatalities and serious injuries on public roadways. The necessity of adopting the Safe System Approach in various situations is acknowledged in all three efforts. The Safe System Approach is in line with the expanding number of Vision Zero goals, initiatives, and action plans being implemented across the United States. While Vision Zero describes the goal and Safe System outlines the strategy, both acknowledge that crashes cannot be entirely prevented [3]. The Safe System Approach asserts that no one should be killed or badly wounded as a result of a collision while utilizing the road system, and that achieving this goal is a shared duty of all parties concerned [6].

In 2018, in collaboration with the Vision Zero Network, the Institute of Traffic Engineers (ITE) received a Road To Zero Grant, to advance speed management within the context of a Safe System Approach in the United States. Laws of physics dictate that greater harm will occur at higher speeds, and that heavier vehicles will inflict more harm on others [21]. As such, a fundamental strategy in the Safe System Approach is to reduce speed in the presence of vulnerable road users [4].

Federal Highway Administration (FHWA) has taken several steps to promote the Safe System Approach across the country, including developing marketing materials, examining the relationship between the Safe System Approach and the Highway Safety Improvement Program (HSIP), assisting Vision Zero communities in incorporating the Safe System Approach into their action-planning process, establishing a Safe System framework for intersections, and partnering with the ITE to develop a Safe System Strategic Plan for the United States [12]. FHWA also launched a primer on the Safe System Approach for pedestrians and bicyclists which will be discussed in detail in section VIII.



Achieving Pedestrian Safety in California

Caltrans has begun working to improve pedestrian safety by introducing a new safety paradigm. Caltrans' 2020–2024 SHSP, as well as the 2020–2024 Caltrans Strategic Plan, have four safety-related pillars. Implementing the Safe System Approach is one of these pillars [3]. Caltrans' Pedestrian Safety Improvement Monitoring Pilot Program, which was launched in 2016, was able to acquire more funds and resources because of the institutional commitment to the Safe System Approach. Caltrans will collaborate with the California Office of Traffic Safety, which is investing more than \$8 million on initiatives to ensure that pedestrians have safe and fair access to roadways. The California Transportation Commission recently granted \$100 million in funding for projects aimed at improving pedestrian infrastructure [9].

Safe System for Intersections

In 2019, 10,180 persons were killed in intersection and intersection-related collisions, accounting for almost a quarter of all deaths on U.S. roads [6]. As a result, the FHWA funded the creation of a Safe System for Intersections (SSI) framework and methodology, which is a first step toward developing objective and implementable assessments that reflect fundamental Safe System concepts. When safety performance function models were not available, Massachusetts Department of Transportation (MassDOT) used the SSI technique to evaluate design for two irregular, nontypical intersections. The SSI technique takes advantage of data that is often accessible early in the project development life cycle, such as posted speed limits, yearly daily traffic numbers, and the number of through lanes on connecting roads [6].

While Safe System concepts have been implemented into U.S. intersection planning and design techniques to some level over the previous few decades, there is still considerable potential to further the Safe System Approach. Other state's Departments of Transportation, including California, Florida, Washington, and Virginia, are examining the SSI technique for their intersection improvements, in addition to MassDOT [6].

Roundabouts fit within the Safe Systems concept by reducing the number of conflict locations while also slowing and modifying vehicle trajectories, lowering kinetic energy while maintaining throughput [15]. Roundabouts reduce serious collisions by 78–82 percent by slowing traffic through risky crossings and preventing lethal side impacts [20].

Using an Equity-Informed Approach in Philadelphia

To eliminate traffic-related fatalities, Philadelphia is using an equity-based Safe System Approach. The continuous effort aims to provide all citizens with safe streets and transit alternatives. The city responded in 2016 by adopting a Vision Zero plan to eradicate traffic-related deaths in Philadelphia by 2030. A foundation for safe highway interventions was published in a 2017 action plan. Philadelphia's Vision Zero accomplishments in the first three years included the construction of over 10 miles of protected bike lanes, the launch of a neighborhood slow zone program, 58 miles of completed safety projects, and the passage of legislation allowing an automated speed safety camera pilot on Roosevelt Boulevard, which is one of Philadelphia's deadliest roads. [9].



Source: NJBPRC

V. Fatal and Serious Injuries (FSI) Crashes and Safe System Approach

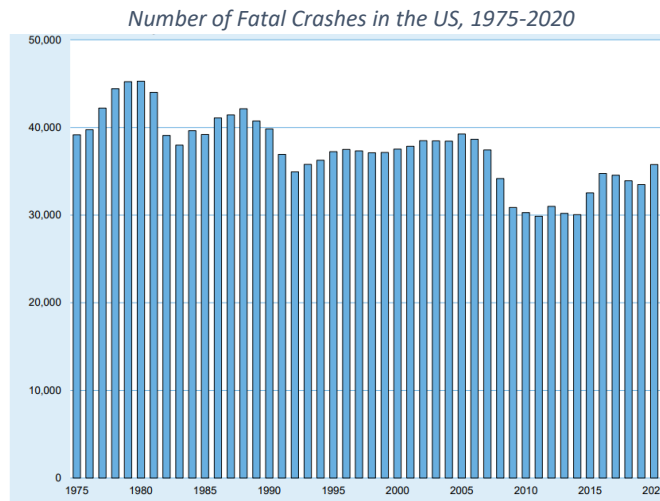
National Definition of Serious Injuries

The US Department of Transportation defines a serious injury using the Model Minimum Uniform Crash Criteria (MMUCC) 4th Edition “Suspected Serious Injury (A)” attribute found in the “injury status” data element. A suspected serious injury is defined as any injury other than fatal that results in one or more of the following [46]:

- Severe laceration resulting in exposure of underlying tissues/ muscle/ organs or resulting in significant loss of blood
- Suspected chest, skull or abdominal injury other than bruises or minor lacerations
- Broken or distorted extremity (arm or leg)
- Paralysis
- Crush injuries
- Significant burns (second and third degree burns over 10% or more of the body)
- Unconsciousness when taken from the crash scene

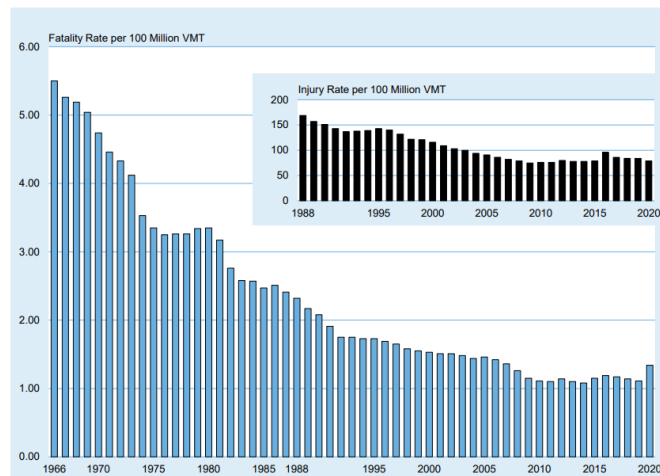


Source: FHWA



Source: NHTSA [44]

Motor Vehicle Fatality and Injury Rates per 100 million VMT, 1966-2020

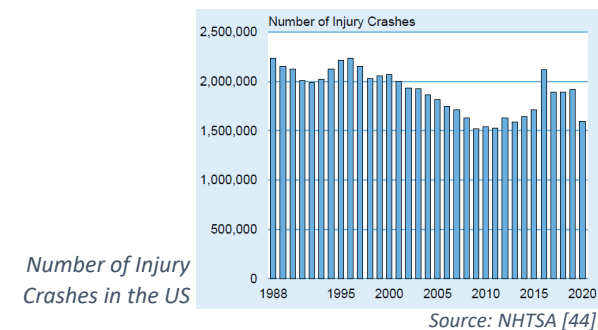


Source: NHTSA [44]

National FSI Trends

In its yearly report “Traffic Safety Facts”, NHTSA provides descriptive statistics regarding traffic accidents including fatalities and property damage.

Since 1975, there has been a drop in the general trend for fatal collisions in the US. However, 38,824 people countrywide died in road crashes in 2020. Since 2007, that statistic represents the greatest number of deaths. [44].



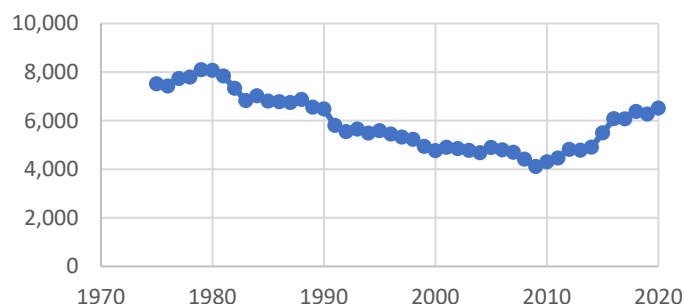
Number of Injury Crashes in the US

In 2020, there were an estimated 22% fewer collisions that were reported to the police than there were in 2019, and there were an estimated 17% fewer injuries [44]. According to the NHTSA study, an injury collision is one in which no one has died but at least one person had one of the following injuries: (a) an incapacitating injury; (b) a visible but not incapacitating injury; (c) a possible, not visible injury; or (d) an injury of unknown severity [44].

Overall, there were fewer collisions and traffic injuries, but the percentage of fatal collisions rose by 6.8%. The death rate jumped to 1.34 per 100 million miles driven by vehicles, a 21% rise from 2019, and the highest level since 2007 [44].

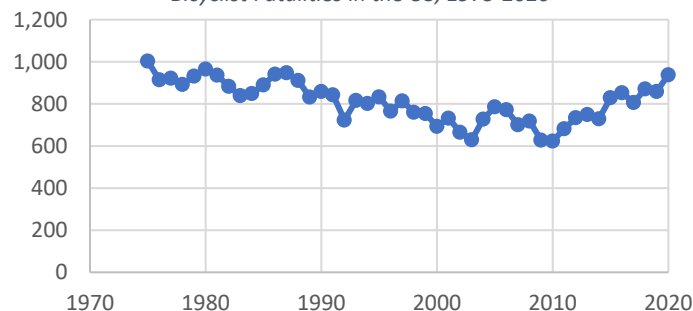
National FSI Trends

Pedestrian Fatalities in the US, 1975-2020



Source: NHTSA [44]

Bicyclist Fatalities in the US, 1975-2020



Source: NHTSA [44]

The pedestrian fatalities saw a decreasing trend till 2010, after which there was an upward trend. In 2020, pedestrian crashed were up 3.9% (highest number since 1989). Similarly, the bicyclist crashes went up by 9.2% (highest number since 1987) [44].

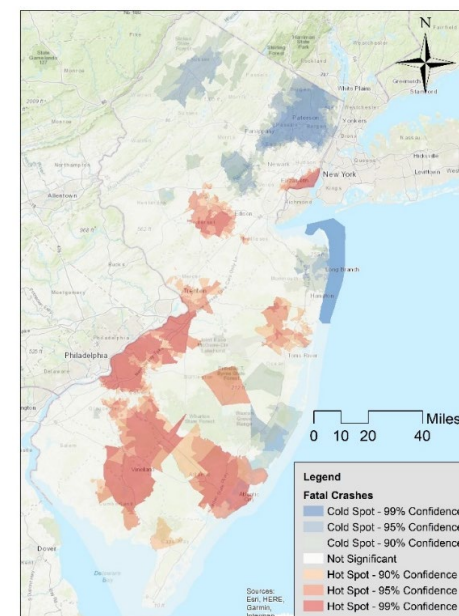
The Safe System Approach starts with a mindset that it is unacceptable to allow deaths and serious injuries to occur on the roads. The goal is to have zero fatal and serious injuries [3].

Crash statistics in New Jersey

In New Jersey, a total of 699 people were killed on the roads and 669 people were injured in 2021. Pedestrians and bicyclists accounted for 35 percent of the total fatalities [1]. As per *The Deadliest Intersections in the United States, 2022*, 4 out of the 10 deadliest intersections for pedestrians in the U.S. are in New Jersey. Over 31,000 non-motorist involved collisions were reported in New Jersey between 2016 and 2020. Around 3% of such crashes resulted in fatalities (4% included pedestrians, and 0.8% involved cyclists) [45].

A study conducted by Hannah, Y. et. al. identified the factors that impact the fatality of non-motorist involved crashes in New Jersey. The paper only studied fatal crashes in New Jersey and did not cover serious injuries. A hot spot analysis was done to visualize the distribution of fatal crashes in New Jersey between 2016-2020. Hot spots were identified in southern New Jersey; namely, in Cumberland County, Atlantic County, Trenton City and Camden City. Other hot spots in central and northern New Jersey are identified in Lakewood, Elizabeth and New Brunswick [45].

The study found that the **sidewalk and crosswalk** infrastructure are a major factor in reducing crash severity. **Light conditions** are a strong indicator of fatality risk for both pedestrian and bicyclist-involved crashes. Even when dark, having streetlights resulted in decreasing the likelihood of a fatality by half, compared to no streetlights [45]. Furthermore, non-motorist involved crashes on roads with **speed limits** exceeding 40 mph were around three times more likely to be fatal for pedestrians and five times for bicyclists. Also, the study found that the risk of a cyclist crash being fatal increased in **low-income areas**, once controlling for all other factors. The study suggested that it might be due to reduced availability of bicycle facilities, including bike lanes [45].



Hot Spot analysis for fatal non-motorist involved crashes between 2016-2020.

Source: Hannah, Y. et. al. [45]

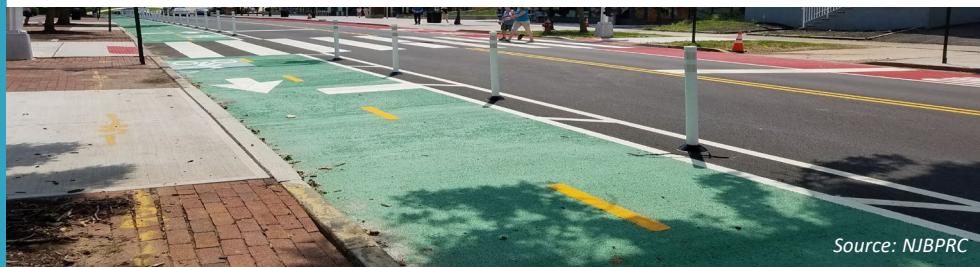
VI. Zero Deaths Principles and Safe System Approach in Strategic Highway Safety Plans

We looked at some case study examples of how other states across the country are incorporating the principles of the Safe System Approach into their Strategic Highway Safety Plans (SHSP). We looked at six states which include Massachusetts, Illinois, Florida, Minnesota, New York, and Rhode Island. The following table shows the number of traffic fatalities in the selected case study states in 2014, 2019, and 2020. Data for 2020 has been added because, due to COVID, many states saw an increase in number of crashes that year. Cells which are highlighted in green show where states were able to reduce the number of fatalities between 2014 and 2019. Looking at the data, we can see that bicyclist fatalities decreased over that period in both Massachusetts and Illinois, while remaining stable in New York. Rhode Island had zero bicyclist fatalities in 2014 as well as 2019 and was able to reduce the number of pedestrian fatalities from 2014 to 2019.

Pedestrian, Bicyclist and Overall Fatalities in the Six States

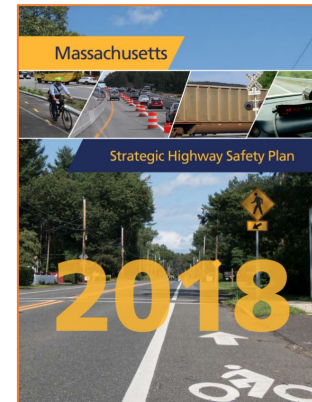
	Pedestrian Fatalities			Bicyclist Fatalities			All Fatalities		
Fatalities	2014	2019	2020	2014	2019	2020	2014	2019	2020
Massachusetts	70	77	52	8	5	10	328	334	343
Illinois	123	173	176	27	12	30	924	1009	1194
Florida	588	713	696	139	161	170	2494	3183	3331
Minnesota	15	47	45	5	11	10	361	364	394
New York	263	268	231	46	46	47	1039	931	1046
Rhode Island	14	8	17	0	0	2	52	57	67

Source: NHTSA



Source: NJBPRC

Case Study: Massachusetts



Massachusetts' 2018 SHSP envisions a roadway system with zero roadway deaths and serious injuries. To sustain significant progress toward zero deaths, the 2018 SHSP calls for stronger fatality and severe injury targets and proposes aggressive policy and legislative interventions.

Goal: Reduce five-year average fatalities by 12% and serious injuries by 21%

The plan includes 61 specific strategies, 283 direct actions, and 14 Emphasis Areas, including Speeding and Aggressive Driving, Intersection Crashes, Pedestrians, Older Drivers, and Bicyclists.

Strategies for Pedestrians and Bicyclists

Contained within the SHSP are separate Bicyclist and Pedestrian Action Plans. The recommended strategies for pedestrians include *incorporating pedestrian safety elements into infrastructure design and engineering; providing resources and funding for municipal safety efforts, including encouraging municipal Vision Zero policies; conducting coordinated pedestrian safety educational campaigns; and improving processes for collecting and analyzing pedestrian crash data to better measure fatalities and serious injuries.*

For the Bicyclist Action Plan, strategies similarly include engineering, education, encouragement, and data collection recommendations. Bicyclist strategies also include enhancing bicycle safety expertise among law enforcement, planners, and public health professionals, as well as integrating bicycle safety activities and data with other plans.

Source: Strategic Highway Safety Planning in Massachusetts 2018

Case Study: Illinois



Illinois launched its most recent SHSP in July 2022 with a vision of a future of zero fatalities where no one loses their life while traveling on Illinois public roadways.

Goal: *2% annual reduction in fatalities and serious injuries based on the 5-year rolling average*

The five-year plan begins immediately with a discussion of the Safe System Approach and its crucial role in Illinois' efforts to achieve zero roadway fatalities. The Safe System Approach serves as a framework for the plan's five emphasis areas, which are Safe Behavior, Safe Road Users and Vehicles, Safe Roads, Post-Crash Care, and Safe System Administration.

Illinois SHSP identifies three priority focus areas: Speeding and Aggressive Driving, Pedestrians, and Roadway Departure. In addition to its embrace of the Safe System Approach, the plan also references the Toward Zero Deaths Assessment Tools that were developed to gauge progress on the Toward Zero Deaths National Strategy as a valuable resource for evaluating the Illinois SHSP.

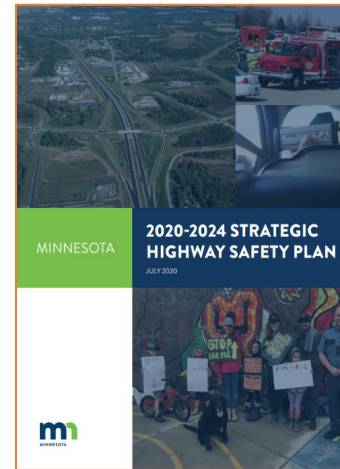
Strategies for Pedestrians and Bicyclists

Strategies to reduce pedestrian and bicyclist crashes are part of the Safe Road Users and Vehicles emphasis area. Pedestrian strategies include a combination of engineering, education, and enforcement countermeasures to reduce pedestrian exposure, improve visibility for pedestrians, improve awareness for pedestrian safety, and slower vehicles speeds to improve safety for pedestrians.

Bicyclist strategies include partnering on bike safety with local, state and federal agencies and organizations; educating roadway users to improve interactions in traffic; conducting research to identify and implement effective policies to improve bicyclist safety at the state, local and governmental levels; and improving infrastructure features to help reduce the number and severity of crashes involving bicyclists using a context-sensitive approach to design.

Source: Illinois Strategic Highway Safety Plan 2022

Case Study: Minnesota



Minnesota's SHSP was released in 2020. The plan begins with a commitment to Minnesota's Toward Zero Deaths program, which has been working for over 15 years with the mission to create a culture where traffic related deaths and injuries are no longer acceptable.

The plan identifies 20 focus areas grouped into four categories: Core, Strategic, Connected and Support Solutions.

Strategies for Pedestrians and Bicyclists

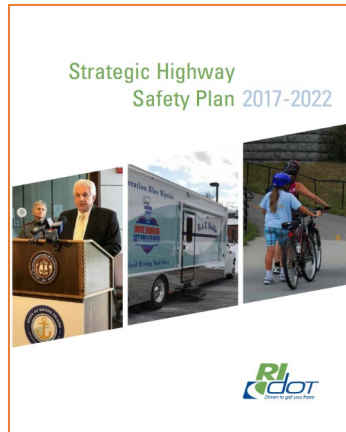
In Minnesota's plan, the Pedestrians focus area falls under the Strategic category, which represents emerging priorities rising in importance due to factors such as changes in prevalence, public perception, and demographics.

Actionable strategies to address pedestrian fatal and serious injury crashes include conducting high-profile pedestrian education campaigns; improving lighting to increase pedestrian visibility, including near transit stops and in rural areas; implementing pedestrians-oriented road design such as sidewalks, mid-block breaks, and bump outs; and developing local and regional Complete Streets plans.

Source: Minnesota 2020-2024 Strategic Highway Safety Plan



Case Study: Rhode Island



Rhode Island's 2017 Strategic Highway Safety Plan references Toward Zero Deaths as a guiding principle and puts forward the goal of halving annual road fatalities and serious injuries by 2030. The plan includes brief summaries of ten emphasis areas, showing background information on the issue, relevant statistics, and strategies for reducing fatalities and serious injuries moving forward.

Goal: *Reduce annual road fatalities and serious injuries by 50% by 2030*

Strategies included in each emphasis area are arranged under the objectives of leadership, criminal justice system, prevention, treatment, evaluation and infrastructure.

Strategies for Pedestrians and Bicyclists

Rhode Island's plan provides strategies for Vulnerable Road Users, which include pedestrians, bicyclists, and motorcyclists. These include:

- Establishing a speakers' bureau comprised of victims who can provide testimonials;
- Re-establishing a highway safety curriculum for K-12 that includes a focus on vulnerable road user safety;
- Installing enhanced pedestrian crossing technologies, such as Rectangular Rapid Flashing Beacons, pedestrian hybrid beacons, and median refuge islands;
- Implementing Complete Streets policies to improve vulnerable user access and mobility; and
- Conducting training for highway engineers and maintenance personnel.

Source: Rhode Island 2017-2022 Strategic Highway Safety Plan

Case Study: Florida



Florida's Strategic Highway Safety Plan was released in 2021 and serves as a framework for plans and activities to improve safety and efficiency on the state's roadways with an ultimate goal of zero fatalities and serious injuries. The plan introduces Florida to FHWA's Safe System Approach to address all elements of a safe transportation system in an integrated manner.



Florida's plan organizes key strategies according to the 4 E's approach to traffic safety and have further identified 4 I's (as shown on right).

Strategies for Pedestrians and Bicyclists

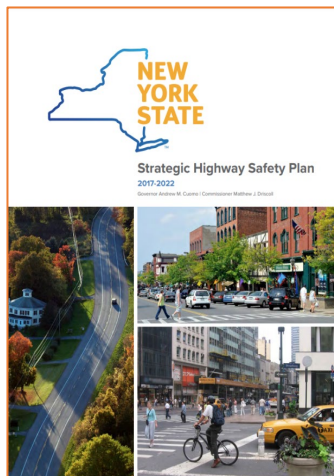
Florida's plan includes a Pedestrians and Bicyclists emphasis area. The plan highlights the critical importance of safety for pedestrians and bicyclists, noting that the state's year-round moderate climate makes walking and bicycling popular activities, as well as the fact that people who bike or walk are among the most vulnerable users of the transportation system.

Focused strategies under the Pedestrians and Bicyclists emphasis area include:

- Developing and deploying engineering best practices such as refuge islands, road diets, separated bike lanes, leading pedestrian intervals, and lighting;
- Educating and training planners, engineers, and law enforcement on the benefits of including pedestrian and bicyclist safety in the planning stages of all transportation projects;
- Providing law enforcement officers with training, tools, and resources to enforce laws;
- Improving medical response protocols; and
- Prioritizing projects that provide safety benefits for people walking and biking.

Source: Florida Strategic Highway Safety Plan 2021

Case Study: New York



New York State's SHSP was released in 2017 and includes six emphasis areas: Intersections, Lane Departure, Vulnerable Users (which includes bicyclists, pedestrians, motorcyclists, and individuals working or traveling in a work zone), Age-Related (which includes young drivers and older drivers), Road User Behavior (which includes impaired driving, occupant protection, and distracted and drowsy driving) and Speed. Together, these emphasis areas comprise 93.2 percent of fatal and serious injury crashes in New York State. In addition, this SHSP examines cross-cutting considerations and emerging areas of study. Emergency Response and Data are included as cross-cutting considerations because they affect all crash types and causes.

The plan also examines the emerging areas of Connected and Autonomous Vehicles. These developing technologies have the potential to greatly reduce roadway fatalities and injuries in the future but will require extensive research and testing before they can be safely implemented.

Strategies for Pedestrians and Bicyclists

New York's plan recognizes that while roads can differ vastly in characteristics such as traffic volume, number of lanes, and functional classification, some users have a greater risk of injury than others. These vulnerable users include pedestrians, bicyclists, motorcyclists, and those who work on the roadway. The plan notes that while most pedestrian crashes occur in New York City, most pedestrian fatalities occur elsewhere.

New York's SHSP seeks to reduce the number of vulnerable user fatalities and serious injuries through a multidisciplinary approach incorporating strategies that focus on engineering, education, and enforcement to address the various contributing factors.

The plan includes the following five strategies to support the Vulnerable Users Emphasis Area:

- Continue to implement infrastructure projects to enhance vulnerable user safety;
- Enhance data processes to easily obtain current vulnerable user data;
- Support policy initiatives to increase vulnerable user safety;
- Continue educational programs related to vulnerable user safety; and
- Enforce traffic laws that pertain to both vulnerable users and motorists.

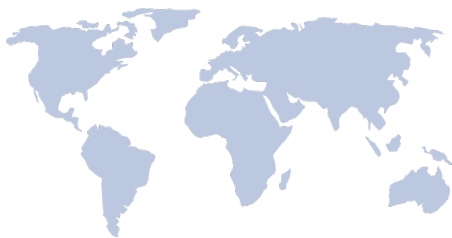
Source: New York State Strategic Highway Safety Plan 2017-2022

While most of the Strategic Highway Safety Plans reviewed made little or no reference to any of the Zero Deaths Initiatives or the Safe System Approach, some of the more recent ones did. The Illinois SHSP fully embraces the Safe System Approach and has formulated its emphasis areas around the Approach's principles. Since the FHWA's adoption of the Safe System Approach occurred relatively recently, it is likely that most of the plans studied were written without clear federal guidance on this topic. However, now that this guidance exists, it is expected that an increasing number of state SHSPs will refer to the SSA framework going forward. Finally, while there is already some alignment between the Safe System Approach and state Strategic Highway Safety Plans, there are opportunities to more strongly integrate SSA principles into state SHSP processes. As outlined in the FHWA's "Integrating the Safe System Approach with the Highway Safety Improvement Program" report, this includes organizing SHSPs around the Safe System Approach's core principles, committing to a goal of zero deaths, focusing on speed management and roadway design, and using proactive data collection and analysis to further equity goals [11].

VII. Safe System Approach Across the Globe

A Safe System approach has been implemented into the plans of a number of nations that have seen the biggest advances in road safety. Sweden and Netherlands were the first to use this notion as part of their “Vision Zero” and “Sustainable Safety” road safety initiatives [28].

Sweden has shown that implementing the Safe System's fundamental principles may have a significant beneficial influence on road safety outcomes. Other countries, such as Australia, New Zealand, and the Netherlands, have recognized the need to explore more effective ways to mitigate the road safety crisis and have modeled their road safety programs after Vision Zero [28].



Sweden

“Vision Zero” was endorsed by the Swedish Parliament in 1997. Its popularity has grown widely since then. In Sweden, the leadership of the Minister of Transport, as well as the director of road safety at the Swedish Road Administration, were instrumental in persuading members of parliament that Vision Zero was a feasible and promising concept. Despite early opposition, Vision Zero was endorsed by a large majority of the Swedish Parliament in October 1997, thanks to their ambitious objectives to enhance road safety and their leadership on the topic [16].

The government launched an 11-point program for Vision Zero in 1999, and further implemented several interventions. Some examples included [10]:

Traffic calming in urban areas which include speed bumps & roundabouts.	2 + 1 roads: An innovative cost-effective solution- three-lane road that consists of two lanes in one direction and one lane in the other, alternating every few miles to enable passing.	New speed limit system: Large-scale speed limit reduction to 19 mph in urban areas and 6-12 mph on several rural road types.
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Monitoring of roadway safety metrics including drunk driving, speeding, seatbelt use, cyclist helmet use, emergency services rescue times, and motor vehicle crashworthiness [27].

According to Vision Zero, the main reason people die or are gravely wounded on the roads is that the kinetic energy that humans are subjected to in a crash, surpasses the energy that the human body can endure. The Swedish Vision Zero is both a long-term aim and an overarching strategy that has compelled Sweden to apply the Safe System Approach [10] and pushed the country to significantly restructure its everyday road safety operations. The media, as well as Sweden's National Society for Road Safety, a non-governmental organization dedicated to improving road safety, played a major role in channeling citizens' demands into the political system [16].

The development and implementation of a Safe System in Sweden was heavily centered on a bottom-up approach to develop and establish new and innovative policy instruments and processes to raise awareness, educate, and mobilize stakeholders and the community about the safety problem, as well as to encourage participation and contribution to solutions to improve road safety outcomes. [16].

Example of a 2+1 Road in Sweden



Source: FHWA [10]

In Sweden, fatalities declined by 50% between 2000 and 2014, and pedestrian fatalities, specifically, declined by 50% between 2009 and 2014 [27]. Roadway fatalities of children seven years of age and younger also plummeted, from 58 in 1970 to one in 2012. Other road safety improvements include [27]:

- Reduction of 90% of fatal crashes on three-lane undivided roads
- Seat-belt compliance at 99%
- 95% compliance with red-light cameras at enforcement sites

Australia

The Safe System Approach was approved by Australian road and transport ministers in 2004 and was included at the federal level in the 2005-2006 National Road Safety Action Plan prepared by the Australian Transport Council in 2005. However, there was a lack of tangible commitment from the Australian government to take necessary actions to implement SSA, even five years after Australia's formal adoption of the initiative [10].

Raised Platform at a High-Speed Roundabout in Victoria



Source: FHWA [10]

The vision for the Safe System Approach was clearer a full decade after it was adopted. Australia set a national goal of achieving zero fatalities and major injuries by the year 2050. It opened the way for long-term, long-lasting improvements in road safety that are more likely to accomplish this ambitious goal. Australia still faces challenges that need to be resolved in order to implement SSA in the long term. The concerns include the need to raise public and policymaker awareness [10]:

- that there is still a serious issue with road safety to be solved,
- that it is unacceptable for there to be any deaths or serious injuries caused by transportation,
- that there are effective measures to lessen the severity of crashes, and
- that roads can be free of accidents and injury in Australia.

The measures taken up by Australia were as follows:

Speed management: A number of locations have speed limits of 20 mph to protect vulnerable roads users. On low-quality, high-risk rural roads, speed limits have been reduced from the default 60 mph to 50 mph or even less [10].

Effective Road Designs: Tools such as the Safe System Assessment Framework (SSAF), and the Extended Kinetic Energy Management Model for Intersections framework (X-KEMM-X) were used to help assess safe system impacts from road infrastructure projects. Both X-KEMM-X and SSAF provided clear information to designers on the safety implications from their decisions [10].

Innovative solutions: By using platforms at intersections, elevated pedestrian crossings, and vehicle-activated speed limit signs at high-speed intersections, the new technologies offer improved ways to control speed and energy at critical areas[10].

New Zealand

New Zealand's first Action Plan in 2011-2012 focused on advancing the Safe Systems Approach through following goals [27]:

- targeting high-risk rural roads and high-risk urban intersections
- improving speed management through public campaigns, safer speeds, and expanding the use of safety cameras
- generating consumer demand for safe vehicles and improving child restraint use
- increasing the safety of motorcycling through training, road treatments, and enforcement
- reducing alcohol/drug impaired driving through regulations, education, and enforcement
- increasing the safety of young drivers through regulations, education, and enforcement
- reducing the impact of high-risk drivers through rehabilitation, regulations, and enforcement
- improving pedestrian and cyclist safety through education and safer infrastructure

New Zealand's road safety has improved substantially in recent decades, much like Sweden's. Despite an increase in traffic volumes, the number of road deaths had decreased by 50% between 1970 and 2018 [27]. However, New Zealand still had one of the highest per capita rates of traffic deaths in the industrialized world in 2007 (about 10 per 100,000 residents). In 2009, the New Zealand National Road Safety Committee proposed "The Safer Journeys Strategy", which was based on the Safe System Approach and envisioned "a safe road system that is increasingly free of road deaths and serious injuries." Over the long-term, the goal of the strategy was to, "Improve the safety of our roads and roadsides to significantly reduce the likelihood of crashes occurring and to minimize the consequences of those crashes that do occur," but it was designed to be implemented through a series of smaller Action Plans (2011-2012, 2013-2015, and 2016-2020) and tailored to address individual community needs [27].

Netherlands

While Sweden is widely renowned for being the first country to use the Safe System Approach, the Netherlands was the first to set quantifiable road safety goals. The Sustainable Safety Program presented by the Netherlands was a proactive method aimed at preventing significant collisions and eliminating the danger of severe traffic injuries. The software was created on the premise that humans' limitations and unpredictable nature are to blame for the bulk of traffic crashes [27].

To fulfill crash reduction targets, the initiative was conducted in two parts. Phase-1 (1998-2002) concentrated on problematic or potentially challenging areas of the road network. The proposed measures included establishing a general urban speed limit of 19 mph, expanding 37 mph zones in rural areas, and categorizing the road network into three functional categories: through function (involving rapid vehicle movements), distributor function (to disperse traffic), and access function (to provide access to the road network and providing access to homes, shops, and offices). Law enforcement and communication efforts to educate road users about the new measures were also prioritized. Phase-2 (2002-2010) focused on assuring the implementation of the revised road classification plans and collecting fresh money to support the suggested activities. Specific measures that have been proposed included expanding the urban and rural speed limits to other areas, as well as setting target speeds in areas where pedestrians and bicyclists interact with traffic and where motor vehicles have greater potential to interact with them [27].

Initial efforts under Sustainable Safety were projected to produce a wide range of benefits including [27]:

- Crash reductions up to 10% by assigning priority for better traffic control at intersections
- Crash reductions up to 20% from speed management efforts
- Uniformity of roundabouts
- Improved safety for other traffic modes
- Increased compliance with seatbelt and helmet regulations

Lessons from international case studies

The experience of pioneering Safe System countries offers lessons about common success factors [16]:

Increase public demand for increased traffic safety

Establish the six Safe System principles as the cornerstone

Drive road safety policy using data

Pilot the use of new tools

Implement safety performance indicators

Effectively convey data about traffic safety

Furthermore, from the four international case studies, it can be observed that there are a number of challenges and new issues that arise from Safe System implementation, which are as follows [27]:

Structural Organization: A Safe System Approach's success depends on vertical integration among stakeholders at all levels of government. The specific framework for putting Safe System in place varies by area and should be tailored to the circumstances. A top-down management system that eventually allowed local towns to take responsibility of their own goals through decentralization worked best in the Netherlands. To achieve buy-in from the public in Sweden, a bottom-up reform was required.



Vulnerable Road Users: The fact that motor vehicle users have seen an increase in safety while other road users have seen less significant improvement underscores the need for a more specific focus on vulnerable road users' safety in the Safe System Approach. This is especially important now since pedestrian deaths are on the rise in the United States.

Integrated Approach to Education and Enforcement: While education and enforcement may be beneficial in and of itself, a real Safe System Approach should attempt to combine these efforts with engineering and emergency response to create a comprehensive plan to enhance road users' health and safety. An early public input program, such as the one implemented in New Zealand, is one model that may be examined in the United States.



VIII. Safe System Approach for Pedestrians and Bicyclists

With pedestrian and bicyclist fatalities on the rise in the United States over the last decade, it is critical to take action to improve safety for the most vulnerable road users. Pedestrians and cyclists, in particular, suffer from underreporting of deaths and injuries. When a lone cyclist crashes his or her bike and dies or is critically injured, the police may not be notified, and the death may not be recorded in the national road mortality statistics. Furthermore, injuries or deaths caused by pedestrians falling down and being injured, or dying while walking on a footway or carriageway are not currently considered road casualties [30].

In 2021, FHWA released a primer on the Safe System Approach for bicyclists and pedestrians, which gives transportation organizations a foundational grasp of the approach and how it relates to safety for both groups of people. The Safe System Approach, at its core, focuses on reducing the risk of fatal and serious injuries to road users, regardless of how they travel [14]. It intrinsically prioritizes pedestrians and cyclists, who are at a higher risk of death and serious injury than someone driving or riding in a motor vehicle. When compared to those traveling inside automobiles, pedestrians and bicyclists account for a greater percentage of traffic deaths in the United States, a trend that can be reversed by setting targets based on deaths and serious injuries rather than crashes [14].

Reduced speeds and enhanced visibility have a major influence on the severity of injuries and the chance of surviving a crash when a pedestrian or cyclist is not protected by a vehicle, especially one equipped with safety technology designed to protect the passengers. Drivers can better recognize pedestrians and bicyclists and have more time to avoid a crash if they keep their speeds modest [14].

When a person is killed or gravely wounded, it is the result of a failure on the part of the transportation agency, the vehicle manufacturer, policymakers, and those who make decisions that impact safety, not just the individuals using the roadway. This shared responsibility aids stakeholders in identifying system features that may be enhanced to increase safety [14].

The safety of pedestrians and bicyclists have been taken in consideration in all the five elements of the Safe System Approach, as illustrated below[14].

Safe Road Users

The Safe System Approach takes into account the safety of all road users, but especially those who are most vulnerable to death or serious harm in the case of a collision, such as bicyclists and pedestrians.



Safe Vehicles

The technology and design of the vehicle are crucial to a Safe System Approach for bicyclists and pedestrians. The approach involves the need to increase the use of proven technology to safeguard individuals both inside and outside of cars.



Safe Speeds

A driver's ability to recognize a pedestrian or cyclist and avert a collision is also influenced by speed. Operating speed is a key aspect in selecting the design of a route and the level of separation required by the Safe System Approach.



Safe Roads

Roadway design and operation plays a critical role in a Safe System Approach. Given their vulnerability to fatalities and serious injuries, it is important to separate bicyclists and pedestrians in time and space from vehicles that have a heavier mass and can travel at greater speeds.



Post-Crash Care

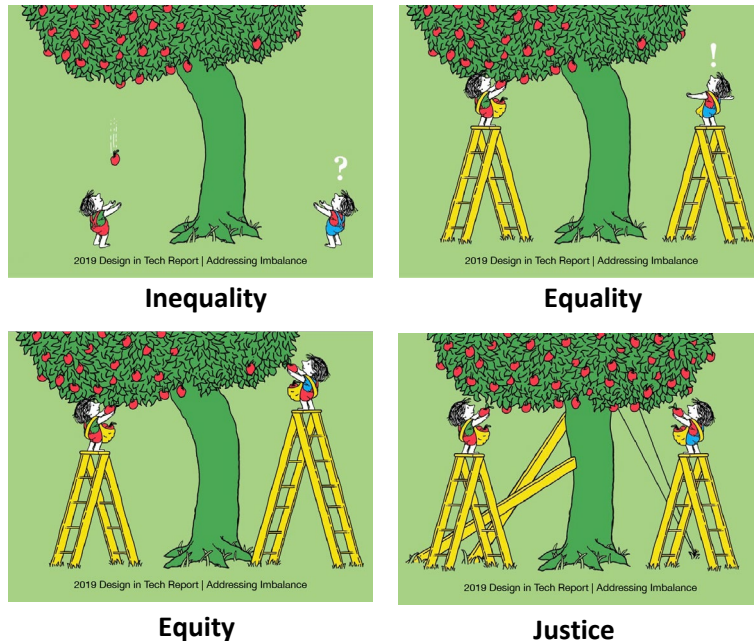
For road safety, emergency medical services (EMS), emergency departments, post-admit hospital care, and rehabilitation are all essential. Because pedestrians and cyclists are more likely to be killed or wounded in a collision, post-crash treatment is much more crucial to their survival.



IX. Equity vs. Equality and Vulnerable Road Users

Equality Vs Equity

Although the words equity and equality may seem identical, their application can have quite different effects on those who are excluded [47]. Equality means giving every person or group the same resources or opportunities whereas equity takes into account that every person has unique circumstances and thus should be given enough resources and opportunities to reach an equal outcome [47].



Source: "Addressing Imbalance," by Tony Ruth for the [2019 Design in Tech Report](#). [External link: open in new](#)

In the illustration above, two people have uneven access to a system, in this instance the fruit-bearing tree. Their access to the fruit isn't equal, even with equally dispersed tools. The equitable option distributes the precise resources that each person needs to obtain the fruit, producing positive outcomes for both persons [47].

Transportation connects people to essential opportunities and resources. In the past and into the present day, people have not had equal access to transportation. Too often, transportation investments divide communities or leave out the people most in need of affordable transportation options, both reflecting and worsening inequality. Thus, it is necessary to understand the difference between equity and equality as it is a key component in the effort to reduce disparities among vulnerable populations. Equity in transportation system is generally concerned with the fair distribution of both the benefits and burdens of the system. Free urban highways, for example, very often cut through poor urban neighborhoods where car ownership is lower than in the suburbs the highways serve. These highways not only create access issues by cutting off neighborhoods from nearby jobs, but they also contribute to air and water quality issues from motor vehicle pollution. Inequitable planning in past decades has unevenly distributed the harmful costs of transportation infrastructure, placing unfair burdens on minority and low-income communities. In numerous cases, these communities experience multiple disparities related to job opportunity, traffic safety, and public health while those same communities are the least able to reap the full benefits of a transportation system that prioritizes motor vehicles.



Source: JHCIRP, ITE, FIA Foundation [20]

Improvements to road safety can promote equity by minimizing the effect of unsafe roads on historically underserved communities [20]. Equity recognizes that different people have different needs, particularly those who are most often vulnerable road users, such as low-income families, people of color, women, immigrants, older adults and children.

Equity in Safe System Approach

The central vision of the Safe System Approach is zero traffic deaths and serious injuries. There is no other acceptable number and getting to zero requires a focus on equity. The objective is to make roads safe for everyone, including those of various ages, abilities, races, and socioeconomic backgrounds. This not only implies, but also demands, investment according to need [20]. By reducing the need for police traffic enforcement, the Safe System Approach can enhance racial equity. The most frequent chance for interactions between citizens and law enforcement is a traffic stop, which continues to be a source of racial and economic injustice [20]. In a Safe System Approach, roads are built in a way that the intuitive behavior is the safe behavior. These designs reduce the need for traffic law enforcement interactions and achieve safety in part by reducing the inherent risks of these instances [20].



Source: NJBPRC

X. Key Takeaways

Creating a safety culture

A safe system needs widespread and long-term political commitment. The Safe System Approach lays the groundwork for these efforts, but it also requires developing practical programs and tools that have an influence on design, investments, and tactics that encourage safe road user behavior. This frequently necessitates creating a safety culture by aligning internal agency cultures with Safe System principles and elements [14]. The Safe System Approach necessitates a culture that prioritizes safety in road system investment choices. To accomplish our goal of zero deaths, everyone must understand that fatalities and serious injuries are unacceptable [18].

Create a sense of urgency

Convincing all stakeholders that a Safe System is the best course of action is a crucial first step in its implementation. People must be convinced that implementing a Safe System is achievable and doable [16].

The Safe System Approach is proven to be cost-effective, with benefits outweighing expenditures by three to four times. It requires strong and enduring leadership to instill a feeling of urgency for change, engage stakeholders successfully, and secure their support for the paradigm shift that prioritizes safety over speed [19].

Involve all stakeholders

Safe System pioneer countries made significant efforts to involve, engage, and persuade all stakeholders whose contributions would be required to make a Safe System work, including politicians, policymakers, road authorities, construction companies, vehicle manufacturers, police, road safety educators and health professionals, as well as the general public and road users in particular [16].



Source: NJBPRC

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Contact Us

New Jersey Bicycle and Pedestrian Resource Center
njbikeped.org

RUTGERS

Edward J. Bloustein School
of Planning and Public Policy

