Safe System Approach for Speed Management

U.S. Department of Transportation
Federal Highway Administration

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

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16. Abstract This report will help practitioners understand the impacts of speed on traffic safety and explore the link between speed management and the Safe System Approach by introducing a five-stage Safe System Approach for Speed Management framework. The five stages are establishing a vision and building consensus for speed management; collecting and analyzing speed and safety data; prioritizing locations for speed management proactively; selecting speed management countermeasures; and conducting ongoing monitoring, evaluation, and adjustment Case studies and examples are interspersed throughout the report and in the appendix, demonstrating how agencies have been able to overcome institutional barriers and rally behind Safe System Approach principles to enact speed management programs with proven, measurable reductions in operating speeds and crashes.			
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GLOSSARY OF TERMS

The following section defines several of the key speed-related terms relevant to the Safe System Approach for Speed Management framework. The definitions provided here are intended to provide clear and consistent use of these terms throughout this report.

Design Speed – Geometric roadway design practices in the United States use design controls and criteria such as those from the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets*, also known as the Green Book. AASHTO defines design speed as "a selected speed used to determine the various geometric design features of the roadway such as horizontal alignment, vertical alignment, and cross-section design elements" (AASHTO 2018).

Kinetic Energy – The energy of a moving object is defined as kinetic energy, and kinetic energy is directly proportional to the object's mass and velocity. The human body has limits for tolerating crash forces; when kinetic energy exceeds a certain threshold, a fatal or serious injury occurs. The Safe System Approach framework prioritizes accommodating human injury tolerances by designing and operating transportation systems to reduce kinetic energy transfer in the event of a crash (FHWA 2020a). The reduction in kinetic energy transfer can be achieved primarily through speed management (Kumfer, LaJeunesse, Sandt, and Thomas 2019).

Operating Speed – Operating speed is defined as a speed at which a driver operates a typical vehicle, or a speed at which the overall traffic operates during free flow conditions. Under free flow conditions, motorist speed is not affected by an upstream or downstream traffic control device (e.g., traffic signal) or by the presence of other vehicles in the same, opposing, or crossing traffic stream. Operating speed is a general term that can refer to speed values such as the average, pace, or 85th percentile speeds (ITE 2016).

Pace – Pace is defined as the 10 mph speed range representing the speeds of the largest percentage of vehicles in the traffic stream.

Self-Enforcing Roadways – A self-enforcing or self-explaining roadway is a roadway that is planned and designed to encourage drivers to select operating speeds consistent with the posted speed limit.

Speed Distribution/85th Percentile Speed – Speed distribution is the arrangement of speed values showing their observed frequency of occurrence. The 85th percentile speed is defined as the speed at or below which 85 percent of free-flowing vehicles are traveling. Conversely, this means that only 15 percent of traffic is traveling faster than the 85th percentile speed.

Speed Limit – Speed limit is defined in Section 1A.13 of the *Manual on Uniform Traffic Control Devices* (MUTCD) as "the maximum (or minimum) speed applicable to a section of highway as established by law or regulation." In the United States, there is no longer a national maximum speed limit; speed limits are established by State or local governments (FHWA 2009).

Speeding – The National Highway Traffic Safety Administration considers a crash to be speeding-related if any driver in the crash was charged with a speeding-related offense or if a police officer indicated that racing, driving too fast for conditions, or exceeding the posted speed limit was a contributing factor in the crash. In the context of speed management, speeding is defined as exceeding the posted speed limit or driving at a speed that is too fast for conditions.

Target Speed – Target speed is the highest operating speed at which vehicles should ideally operate on a roadway in a specific context (ITE 2021).

Vulnerable Roadway User – The definition of "vulnerable road user," provided in 23 U.S.C. 148(a)(15), is a non-motorist—

> "(A) with a fatality analysis reporting system person attribute code that is included in the definition of the term 'number of non-motorized fatalities' in section 490.205 of title 23, Code of Federal Regulations (or successor regulations);" or
>
> "(B) described in the term 'number of non-motorized serious injuries' in that section."

The number of non-motorized fatalities as defined by FARS includes pedestrians, bicyclists, other cyclists, and persons on personal conveyance.

The *Safety in Road Traffic for Vulnerable Users* report defines a vulnerable road user as a person "unprotected by an outside shield, as they sustain a greater risk of injury in any collision witha vehicle and are therefore highly in need of protection against such collisions" (European Conference of Ministers of Transport 2000). Throughout this report, people walking, rolling, or using other kinds of personal conveyances are referred to as vulnerable road users.

EXECUTIVE SUMMARY

Speeding, exceeding the posted speed limits, or traveling too fast for conditions was a contributing factor in almost 29 percent of all fatalities in 2021. Of the 42,939 fatalities that occurred on our Nation's roadways that year, 12,330 were speeding-related—an increase of 7.9 percent from 2020 (Stewart 2023). Speed is fundamental in dictating injury risk for all road users in any crash, especially for vulnerable road users (VRUs) such as pedestrians and bicyclists (Corben 2020). Studies clearly show that higher speeds result in greater impact at the time of a crash, which leads to more severe injuries and fatalities (Elvik 2005; WHO 2008).

The correlation between speed and injury crashes has been well documented throughout the scientific literature on traffic safety, and achieving lower speeds has been proven to save lives and reduce serious injuries. To achieve a truly safe transportation system, road safety practitioners should not only manage speeds but make achieving safe speeds on all roads a cornerstone of their safety policies.

This report will help practitioners understand the impacts of speed on traffic safety and explore the link between speed management and the Safe System Approach by introducing a five-stage framework on the Safe System Approach for Speed Management. These five stages are establishing a vision and building consensus for speed management, collecting, and analyzing speed and safety data, prioritizing locations for speed management proactively, selecting speed management countermeasures, and conducting ongoing monitoring, evaluation, and adjustment.

The report and Appendix include case studies and examples demonstrating how agencies overcame institutional barriers and coalesced on Safe System Approach principles to enact speed management programs with measurable reductions in operating speeds and crashes. These case studies include examples of successful approaches to lowering speed limits, redesigning roadways, collecting data, enforcing speeds with technologies, and working toward network wide realizations of target speeds that improve the safety of all road users.

Key themes highlighted in this report from international and domestic documents and interviews include the following:

- Strategic plans, like Vision Zero, help build public will for speed management practices, and agencies can align those practices with Safe System Approach-based traffic safety goals.
- Speed and safety data are helpful both to guide the speed management program and to build public support for the program.
- As much as practicable, agencies should align speed limits and target speeds to prioritize injury minimization. This alignment often requires changing the roadway environment to slow driver speeds.

1. INTRODUCTION

Speeding, exceeding the posted speed limits, or traveling too fast for conditions was a contributing factor in almost 29 percent of all fatalities in 2021. Of the 42,939 fatalities that occurred on our Nation's roadways that year, 12,330 were speeding-related—an increase of 7.9 percent from 2020 (Stewart 2023). Speed is fundamental in dictating injury risk for all road users in any crash, especially for vulnerable road users (VRUs) such as pedestrians and bicyclists (Corben 2020). Studies clearly show that higher speeds result in greater impact at the time of a crash, which leads to more severe injuries and fatalities (Elvik 2005; WHO 2008).

A nationally consistent approach to speed management can prevent fatalities and serious injuries where speeds are high. This report summarizes both international research and results from established speed management programs to help inform noteworthy practices for speed management in a U.S. context. The recommended approach to speed management is underpinned by the Safe System Approach. The Safe System Approach is an internationally recognized best practice for reducing and ultimately eliminating fatalities and serious injuries for all road users and consists of the following five elements: safe speeds, safe roads, safe vehicles, safe road users, and post-crash care. Principles of a Safe System Approach include the following:

- Death and serious injury are unacceptable.
- Humans make mistakes.
- Humans are vulnerable.
- Responsibility for road safety is shared.
- Traffic safety is proactive.
- Redundancy is crucial (for preventing death and serious injury).

The key elements and principles of the Safe System Approach are shown in **Figure 1**.

Source: Doctor, M., Ngo, C., Ocel, N., Scurry, K., and Shaw, J. (2020). "Safe System – An Approach Toward Zero Traffic Deaths." FHWA's *Safety Compass Newsletter 14*(3), 4-6.

Figure 1. The Safe System Approach.

This report highlights the importance of achieving target speeds and kinetic energy management on all roads in a network. Emphasis is placed on the overlap of the safe speeds and safe roads elements of the Safe System Approach, as the appropriate target speed for a road depends on the road design, roadway context, and desired mix of roadway users. The target speed can be achieved by aligning the road design and speed limit with the intended purpose of the roadway while implementing speed management countermeasures to reduce operating speeds, as needed. The correlation between speeds and injury crashes has been well documented throughout the scientific literature on traffic safety, and achieving lower speeds has been proven to save lives and prevent serious injuries. Therefore, a Safe System Approach strives to manage speeds so that impact forces experienced by road users are not beyond their physical tolerances (Doecke, Kloeden, Dutschke, and Baldock 2018).

This informational report will help practitioners understand the impacts of speed on traffic safety and make clear the link between speed management and the Safe System Approach by introducing a five-stage framework for Safe System Approach for Speed Management. These five stages (shown below) are explained in greater detail in **Chapter 3**.

1. Establishing a vision and building consensus for speed management.
2. Collecting and analyzing speed and safety data.
3. Prioritizing locations for speed management proactively.
4. Selecting speed management countermeasures.
5. Conducting ongoing monitoring, evaluation, and adjustment.

The Appendix of this report contains 10 case studies that provide agencies with useful models as to how other traffic safety stakeholders have implemented components of the Safe System Approach for Speed Management framework. References to these case studies are highlighted with text boxes in relevant sections throughout this report.

1.1. The National Roadway Safety Strategy's Vision for Speed Management

In January 2022, the U.S. Department of Transportation (USDOT) released the first *National Roadway Safety Strategy* (NRSS) to inform priorities and strategies across the entire department (USDOT 2022a). This new strategy proclaimed that the USDOT's priority "is to make our transportation system safe for all people." The Safe System Approach to preventing fatalities and serious injuries is foundational to the NRSS. In fact, the strategy lists four key actions (to be led by FHWA and NHTSA) that the department will take to work towards the Safe System principle of safer speeds, and one of these actions is a robust, multimodal speed management program. To achieve safer speeds, "[t]he Department believes it is important to prioritize safety and moving individuals at safe speeds over focusing exclusively on the throughput of motor vehicles." This emphasis on safety will require a "multi-faceted approach that leverages road design and other infrastructure interventions, speed limit setting, education, and enforcement" (USDOT 2022a). The Safe System Approach for Speed Management framework discussed in this report dovetails with the multi-faceted speed management approach emphasized by the NRSS.

2. THE RATIONALE FOR A SAFE SYSTEM APPROACH FOR SPEED MANAGEMENT

Speed, as is established throughout this chapter's review of the scientific literature on traffic safety, is one of two primary factors that determines whether a crash is fatal or results in a serious injury, with vulnerability being the second. Speed directly informs how safe roads are for all roadway users. For this reason, speed management is a key component of the NRSS as well as a key element of the Safe System Approach. This chapter explores the link between speed and traffic safety by highlighting key international and domestic research. It also presents the Safe System Approach as a potential strategy for mitigating the harm that high speeds can cause on U.S. roadways. **Table 1** steps through each element of a Safe System Approach (shown in **Figure 1**) with a detailed explanation of each, a discussion of how they each relate to safe speeds, and links to relevant research.

Table 1. Safe System elements and how they relate to safe speeds.

Element	Detailed Explanation	Connection to Safe Speeds
Safe Speeds	Humans are unlikely to survive high-speed crashes. Reducing speeds can accommodate human injury tolerances in three ways: reducing impact forces, providing additional time for drivers to stop, and improving drivers' ability to see the surrounding roadway.	The Safe Speeds element is inevitably at the heart of a speed program (Zia, Harris, and Smith 2019).
Safe Vehicles	Vehicles can be designed and regulated to minimize the occurrence and severity of collisions using safety measures that incorporate the latest technology.	Safe vehicle technologies that encourage drivers to travel within the speed limit, such as Intelligent Speed Adaptation (ISA), are available. These tools provide drivers with important feedback regarding speed limits and operating speeds (European Commission 2018).
Safe Road Users	The Safe System Approach addresses the safety of all road users, including those who walk, bike, drive, ride transit, and travel by other modes. This element also highlights the need of the transportation system to act equitably when it comes to different forms of road users (USDOT 2022a).	The system can be designed to encourage road users to travel at safe speeds. For example, police enforcement is often one element of a successful speed management program (Turner, Khoo, Bosher, and Trumper 2014), and immediate safety benefits can be achieved through enforcing existing speed limits, especially with automated technologies.

Table 1. Safe System elements and how they relate to safe speeds. (continued)

Element	Detailed Explanation	Connection to Safe Speeds
Safe Roads	Designing to accommodate human mistakes and injury tolerances can greatly reduce the severity of crashes that do occur.	Safe roads and safe speeds are two elements with a significant connection to each other. Speed management infrastructure that encourages road users to drive at lower speeds is critical in creating a long-term safe system.
Post-Crash Care	When a person is injured in a collision, they rely on emergency first responders to quickly locate them, stabilize their injury, and transport them to medical facilities. Post-crash care also includes forensic analysis at the crash site, traffic incident management, and other activities.	Consideration should be given to speed management infrastructure to reduce the time and effort it takes for first responders to get to the location of a crash. For example, vertical deflection devices on emergency services routes should be assessed to ensure that any safety benefit for road users is not outweighed by increases in the emergency response times.

Source: FHWA.

Each section of this chapter explores research related to speed and how it corelates to crashes, speed limits, roadway design, and vehicle design. Finally, this chapter presents an overview of speed management and explains how it fits within the Safe System Approach.

2.1. Speed and Crashes

Speed is one of the most critical factors in the outcome of motor vehicle crashes. Speed affects a driver's ability to react to other objects on the road, as well as the survivability of road users inside and outside of vehicles (National Safety Council 2022). Although speeding-related fatalities in the United States (shown in **Table 2**) steadily declined from 2010 to 2019, 2020 statistics indicate that there was a 17 percent increase in speeding-related fatalities, resulting in 11,258 fatalities (NHTSA 2022b). NHTSA statistics for 2021 also indicate an additional 7.9 percent increase in speeding-related fatalities, for a total of 12,330 such fatalities in 2021 (Stewart 2023). Moreover, international estimates indicate that up to 60 percent of roadway fatalities may be speeding-related (Soames and Brodie 2022).

However, focusing on speeding alone minimizes the actual impacts of speed itself on traffic safety. Speed is one of the determinants of how much kinetic energy is released in a crash (IIHS 2021), and years of research and evaluation have shown that it is positively associated with both the frequency of crashes and the severity of injuries sustained in those crashes (Elvik 2005; WHO 2008). Therefore, a singular focus on speeding ignores the impact that even high, legal speeds can have on safety, since human injury tolerance can be exceeded even when drivers comply with the legal speed limit. Speed management efforts are intended to reduce harmful speeds rather than just control speeding behavior. Keeping this in mind, this report focuses on the impacts of speed on traffic safety rather than speeding alone.

Table 2. Speeding-related fatalities and injuries in the United States, from 2010 to 2021.

Year	Speeding-Related Fatalities	Speeding-Related Fatalities as Percentage of Total Fatalities	Speeding-Related Injuries	Speeding-Related Injuries as Percentage of Total Persons Injured
2010	10,508	32%	464,000	21%
2011	10,001	31%	460,000	21%
2012	10,329	31%	503,000	21%
2013	9,696	19%	383,000	17%
2014	9,283	28%	339,000	14%
2015	9,723	27%	348,000	14%
2016	10,291	27%	377,000	12%
2017	9,947	27%	362,000	13%
2018	9,579	26%	359,000	13%
2019	9,478	26%	326,000	12%
2020	11,258	29%	308,013*	13%*
2021	12,330	29%	*i*	*i*

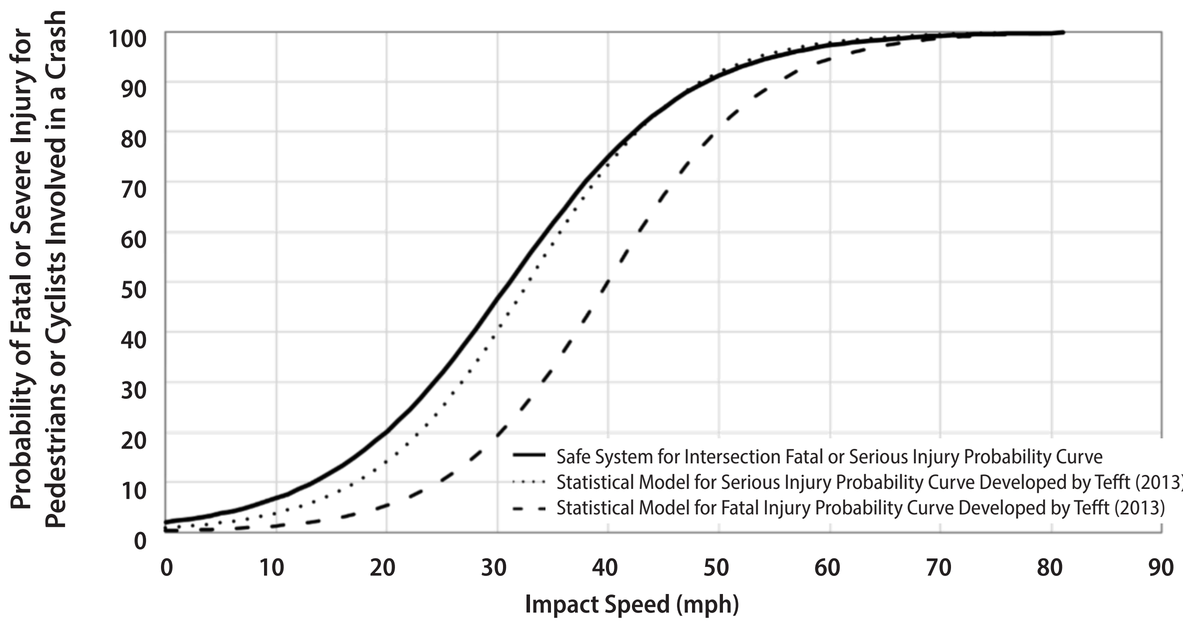
i = injury data unavailable for 2021.
* Estimate

Source: For data up through 2020, see NHTSA. 2022. "Traffic Safety Facts: Speeding." DOT HS 813 320. Washington, DC: NHTSA. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813320. For 2021 data, see T. Stewart. 2023. *Overview of Motor Vehicle Traffic Crashes in 2021*. DOT HS 813 435. Washington, DC: NHTSA.

2.1.1. Human Tolerance to Speed

Humans can physically withstand a limited amount of force if a crash occurs, and this tolerance is even more stark if the victims of a crash are young or old. As the speed of a vehicle involved in a crash increases, so does the kinetic energy released and the likelihood of the crash resulting in a fatality or serious injury. This relationship between speed and safety is especially important for roadway users outside of vehicles who cannot rely on vehicle bodies or technologies to protect them.

Figure 2 shows probability curves indicating that as impact speed increases, the likelihood of a pedestrian being killed or seriously injured also increases (Porter et al. 2021; Tefft 2013). This figure shows that crashes occurring at speeds as low as 10 mph can result in serious or fatal injuries for pedestrians, while other research shows that crashes at 20 mph can result in serious or fatal injuries for people inside motor vehicles (Washington Injury Minimization and Speed Management Policy and Guidelines Workgroup 2020). Even these estimates of injury tolerance may be overestimates because they do not necessarily account for variations in pedestrian age and physiology or the types of vehicles involved. Younger and older pedestrians are likely more susceptible to head injuries in crashes (Sandt, Brookshire, Heiny, Blank, and Harmon 2020). One study conducted in North Carolina that examined crash and emergency department data determined that nearly one-third of all pedestrian crash injuries corresponded to collisions where the vehicle was traveling below or at only 5 mph (Harmon, Hancock, Rodgman, Sandt, and Thomas 2021), indicating that roadway environments may be unsafe for VRUs even when operating speeds are relatively low.



Source: Tefft, B. (2013). Impact Speed and a Pedestrian's Risk of Severe Injury or Death. *Accident Analysis & Prevention* 50: 871–878.

Figure 2. Comparison of pedestrian risk curves.

Thankfully, research does indicate that even moderate changes in speed can substantially improve safety outcomes for all road users. The World Health Organization (WHO) (2008) highlights this effect, showing that a 15 percent reduction in mean speed can decrease the risk of fatal and serious injury crashes by almost 50 percent, although this finding is more relevant to higher-speed collisions (i.e., those above the curves shown in **Figure 2**). Etika (2018) reports similar findings, indicating that an average speed increase of 0.6 mph will typically result in a 4 to 5 percent increase in the risk of a fatality occurring. This increased risk is even more prominent with pedestrians. Peden et al. (2004) found that an increase in speed from 19 mph to 31 mph can increase risk of a fatality by 70 percent for pedestrians.

2.2. Speed Limits and Safety Outcomes

Speed limits and operating speeds are connected, so speed limits are a relevant factor in traffic safety outcomes. Agencies must follow the requirement contained in Section 2B.13 of the MUTCD to conduct an engineering study when identifying an appropriate non-statutory speed limit for a roadway. In this process, agencies collect speed distribution data while noting traffic volumes (including pedestrian and bicycle volumes), relevant design elements (e.g., horizontal curvature), placement of lighting and traffic control devices, and crash history (Forbes, Gardner, McGee, and Srinivasan 2012). Many agencies then place significant weight on the speed distribution data, often setting posted speed limits that directly correspond to either the 50th percentile speed or the 85th percentile speed, depending on State and local legislation and practices. Many States and jurisdictions legally require the use of the 85th percentile speed for posted speed limit setting.

However, the 85th percentile speed may not correspond to safe operations for every roadway context. Drivers often underestimate their own travel speeds by 10 percent at higher speeds (e.g., 70 mph) and 30 percent at lower speeds (e.g., 35 mph), resulting in operating speeds higher than posted speed limits that are potentially unsafe (Grembek et al. 2020). The 85th percentile approach may also not account for additional considerations, such as crash experience, road characteristics, road context, and presence of pedestrians and bicyclists. Setting context appropriate speed limits is a key part of the Safe System Approach for Speed Management framework.

2.2.1. Setting Safer Speed Limits

Much of the current surface transportation system in both the United States and abroad was not designed with human injury tolerance in mind (Peden et al. 2004). In other words, the current system produces speeds that may not be safe for all road users. International researchers and road agencies have identified potential injury minimization speed limits that are more likely to prevent fatalities and serious injuries. These speed limits, like those highlighted by Jurewicz and Turner (2010) and shown in **Table 3**, vary by roadway classification but are rooted in the Safe System Approach. Other research has demonstrated that changing speed limits can achieve a 4 mph reduction in 85th percentile speed and 25 percent reduction in casualty crashes on average (Hillier, Makwasha, and Turner 2016). This has been shown in other literature to vary greatly depending on the speed environment and levels of enforcement.

An analysis of speed limit evaluation studies showed that lowering the speed limit on high-speed roads has a greater effect on mean operating speeds than lowering the speed limits on low-speed roads (even for the same reduction in speed limit) (Jurewicz and Hall 2009). However, even changes in lower speed environments can produce safety benefits, especially for vulnerable road users. For example, a 6.2 mph speed limit reduction may reduce mean operating speeds on average by approximately 2.5 mph (Jurewicz and Hall 2009). **Table 4** summarizes these documented safety benefits corresponding to speed limit changes. This international research demonstrates that if speed limits are proactively lowered to address safety risks and implemented alongside speed management treatments, practitioners can expect that operating speeds and crash frequencies will decrease.

Table 3. Example of a proposed safer speed limit model in the Netherlands, alongside the existing general speed limits.

Roadway Context	General Speed Limits in the Netherlands	Safer Speed Limit to Minimize Injuries
Single-lane rural road (likely only run-off-road collisions)	62 to 75 mph	75 mph
Rural collector with no pedestrian or bicyclist activity and physical separation between driving directions	62 mph	50 mph
Rural collector with no pedestrian or bicyclist activity but no physical separation between driving directions	50 mph	43 mph
Rural access road	37–50 mph	25–50 mph
Intersections on rural collectors with pedestrian and bicyclist activity	37 mph	19 mph
Intersections on rural collectors without pedestrian and bicyclist activity	50 mph	31 mph
Urban arterial	43 mph	43 mph
Urban collector	31 mph	31 mph
Urban local road	19 to 31 mph	19 mph
Intersection on urban collector	31 mph	31 mph
Intersection on urban local road	19 to 31 mph	19 mph
Pedestrian and bicyclist crossing	-	19 mph
General context when head-on-crashes are possible	-	43 mph
General context when side impact crashes are possible	-	19 mph

- No data.

Source: C. Jurewicz and B. Turner. (2010). *Infrastructure/Speed Limit Relationship in Relation to Road Safety Outcomes*. Sydney, New South Wales: Austroads.

Table 4. Summary of speed and crash study results.

Reference	Country	Speed Limit Reduction	Mean Speed Change	Crash Reductions
Finch et al. (1994)	Switzerland	81 to 75 mph	3 mph	Fatal crashes −12%
Sliogeris (1992) cited in Patterson et al. (2002)	Australia	68 to 62 mph rural freeways	-	Injury crashes −19%
Nilsson (1990) cited in Stuster et al. (1998)	Sweden	68 to 56 mph	9 mph	Fatal crashes −21%
Peltola (1991) cited in Stuster et al. (1998)	UK	62 to 50 mph	2 mph	Crashes −14%
Frith and Toomath (1982) cited by Patterson et al. (2000)	New Zealand	55 or 60 to 50 mph rural* default	8–10 mph	Fatalities −37%; Serious injuries −24%; Minor injuries −22%*
Engel and Thomsen (1988) cited in Cameron and Elvik (2008)	Denmark	37 to 31 mph urban default	2–3 mph	Fatalities −24% Serious Injuries −7% Minor Injuries −11%
Scharping (1994) cited in Stuster et al. (1998)	Germany	37 to 31 mph	-	Crashes −20%
Hoareau, Newstead, and Cameron (2006) cited in Cameron and Elvik (2008)	Australia (Victoria)	37 to 31 mph local roads	1–2 mph	Fatal crashes −21%; Serious injury crashes −3%; Minor injury crashes −16%; Casualty crashes−12%; Pedestrian fatal crashes −25%; Pedestrian serious injury crashes −40%
Kloeden, Woolley, and McLean (2007) cited in Cameron and Elvik (2008)	Australia (South Australia)	37 to 31 mph local roads	2.4 mph	Fatalities −40%; Serious injuries −20%; Minor injuries −23 to −26%; Casualty crashes −20%
Walsh and Smith (1999) cited in Archer et al. (2008)	Australia (Queensland)	37 to 31 mph local roads	3 mph	Fatal crashes −88%; Casualty crashes −23%
Hoareau and Newstead (2004) cited in Archer et al. (2008)	Australia (Western Australia)	37 to 31 mph local roads	0.6 mph	Casualty crashes −21%; Pedestrian casualty crashes−51%
Green, Gunatillake, and Styles (2003) cited in Archer et al. (2008)	Australia (ACT)	37 to 31 mph local roads	-	All crashes −2.1% (not significant)
Hu and Cicchino 2020)	Boston, U.S.A.	30 to 25 mph	0.3% decrease	-

- No data.

*For reference, urban areas experienced reductions of 15%, 9%, and 4% respectively over the same period.

Source: FHWA.

2.2.2. The Importance of Reviewing Speed Limits

The basis of any speed management approach should be the setting of speed limits. As demonstrated in **Table 4**, research demonstrates that a proactive approach to reviewing and then lowering speed limits, if appropriate, can produce significant safety benefits (Jurewicz and Turner 2010).

Although it is often desirable to implement infrastructure changes to reduce serious crash risks, this might not be easily achieved at a network level and could require significant time, resources, and funding to accomplish. Therefore, some agencies begin with a proactive evaluation of speed limits and lower those that correspond to the greatest risk in the roadway network. The power of speed limit changes is that they can be implemented much faster and at a far greater scale than transformational infrastructure changes. One proactive approach to speed limit setting, the Infrastructure Risk Rating (IRR) model (Zia, Harris, and Smith 2019), has been demonstrated to produce changes in both mean operating speeds and reductions in crashes. Research also shows that while speed limit lowering does impact travel time, a key concern for road users when it comes to speed change, the effect is often minor (Waka Kotahi 2022). These points combined make speed limit changes a key consideration when wanting to make a transformational change to the risk across a large network within a reasonable time.

2.2.3. International Speed Limit Practices

International traffic agencies have implemented speed limit changes in coordination with infrastructure and planning changes as part of a Safe System type framework to manage speeds and improve traffic safety. Some example programs include the following:

- **Sustainable Safety in the Netherlands:** As part of the Dutch Sustainable Safety approach, practitioners carefully examined roadway functional classification and developed strict criteria for speed limit setting alongside operational and design considerations. In the Netherlands, certain rules were determined to limit potentially fatal conflicts for several different scenarios. These include strict speed limits (e.g., 50 mph for rural distributor roads), separated bike lanes for urban distributor roads with 31 mph speed limits, and lower speed limits (i.e., speed limits below 31 mph) when separation cannot be provided for bicyclists. From 1998 through 2007 it is estimated that more than 25,476 miles of 19 mph speed limits and more than 20,505 miles of 37 mph speed limits were implemented in the Netherlands (often with supporting infrastructure). After this implementation, around 70 percent of urban roads had a speed limit of 19 mph and almost 60 percent of all rural roads had a speed limit of 37 mph. The consistent lowering of speeds was achieved through almost all road authorities designing a categorization plan for roads on their road network. Together with a range of other road safety infrastructure improvements, these measures prevented an estimated 120 to 145 fatalities per year (Weijermars and Wegman 2011).

- **Slow-Speed Zones**: Some international agencies have implemented slow-speed zones to address risk of traffic injury with a combination of speed limits and physical design measures. In this speed management approach, agencies set target speeds of 20 mph or lower within a designated area (e.g., a residential area between major arterials) rather than on a single roadway. Agencies then alter design features within this area to ensure consistent, self-enforcing roadways. Designating slow-speed zones rather than making piecemeal modifications to roadway segments has been demonstrated to be more effective than urban slow-speed zones without self-enforcing roadway designs. An analysis of 20 mph zones in London found a 46 percent reduction in fatal and serious injury crashes overall (Sharpin et al. 2021). In 2011, Japan introduced 19 mph zones. Over 1,100 of these zones were implemented by the end of March 2014, and these are being complimented by new zones with even lower speed limits. Analysis of large towns in Japan found that many have gone an entire year without a single fatality. While this may not be due to Safe System policies in isolation, these zones do show that becoming a genuine “zero deaths” city is possible (ITF 2016).

2.3. Speed and Roadway Design

Previous sections illustrated the link between speed limits, operating speeds, and safety. Speed is also connected to roadway design, both as a design element for specific geometric features of a roadway (e.g., curve radii) and as an operational characteristic of the roadway that can be influenced by additional design elements, like roadside features (AASHTO 2018). Designing roadways using higher design speeds can cue drivers that higher operating speeds are appropriate, even if posted speed limits are lower than design speeds.

Rsearch has demonstrated that non-access-controlled roadway environments that provide visual friction or “hem in” drivers can induce lower speeds. Roadside features that produce visual friction, like on-street parking, sidewalks, or downtown locations, are associated with lower speeds, while roadways with wide shoulders, large building setbacks, and residential-type land development were associated with higher speeds (Ivan, Garrick, and Hanson 2009). Creating visual friction through roadside design can be an effective way to slow traffic, particularly on low-speed roadways with pedestrian and bicyclist activity. On higher speed, access-controlled facilities, agencies should ensure that curves can be navigated safely and may consider roadside designs that minimize the severity of run-off-road crashes by referring to the *AASHTO Roadside Design Guide* (AASHTO 2011).

AASHTO’s *A Policy on Geometric Design of Highways and Streets* (aka, the Green Book) also affords some flexibility when specifying roadway cross-sectional elements in relation to the design speed and the context of the facility. In the 7th Edition of the Green Book, AASHTO notes: “[o]n lower-speed facilities, use of above-minimum design criteria may encourage travel at speeds higher than the design speed” (AASHTO 2018). Infrastructure owners and operators may design narrower cross-sections to maintain visual friction and restrict speeding behavior where appropriate for the context. AASHTO provides flexibility for the use of 10 or 11 ft lanes to accommodate lower speeds in urban environments. AASHTO also encourages roadway designers to select a target speed when roads are designed for walkable or mixed-use urban environments, with the target speed equal to the highest speed appropriate to provide a safe and comfortable environment for multimodal use (AASHTO 2018).

2.4. Speed and Vehicle Design

It is also worth noting that vehicle designs have changed substantially over the years, resulting in generally larger and heavier vehicles that are also capable of greater acceleration and speed than those in decades past. Sport utility vehicles (SUVs) now compose a greater proportion of the U.S. vehicle fleet (IIHS 2020), and notwithstanding increases in protection of vehicle occupants, pedestrians and bicyclists are likely at greater risk as a result of these vehicle fleet changes. Both the increased speed and mass of these larger vehicles correspond to higher likelihoods of people being killed or seriously injured in crashes, especially those outside vehicles. Research shows that while injury outcomes remained relatively similar between vehicle groups at low speeds (lower energy) and at high speeds (typically fatal crash injuries), there was an elevated risk of injury for pedestrians at medium speeds (greater than 19 mph) due to SUV design (Monfort and Mueller 2020).

2.5. Speed and the Safe System Approach

The Safe System Approach lies at the core of the NRSS (USDOT 2022). This approach represents a paradigm shift in that it recognizes road safety as a shared responsibility. It acknowledges that humans are vulnerable and make mistakes, so it is critical for all responsible traffic safety practitioners to recognize that death and serious injuries are unacceptable and to proactively build in redundancies to the surface transportation system. This revised emphasis is important because of the following:

- Blaming individuals after incidents occur, often due to distraction or human mistakes that all drivers make, does not address the underlining risk that exists for future crashes to occur.
- Instead, the road system should be more human-centric and allow for reasonable human mistakes without those mistakes resulting in fatalities or serious injuries.
- Aligning speed limits to higher operating speeds presumes that most drivers can correctly interpret a road environment and select a safe operating speed. This is not always the case. Roadways are often designed in ways that facilitate high speeds, and humans are often not cognizant of the risks posed by high speeds. It is not realistic to assume that drivers can determine safe speeds within mere moments of entering a new road environment. For example, in a rural environment, drivers will often misjudge the correct speed to navigate curves, especially curves that are out of context (i.e., require a large speed change to safely negotiate) and intersections, even where they have priority.

2.6. Integrating Speed Management and Systemic Safety in the Safe System Approach

Vision Zero was the origin of several countries' shifts toward the Safe System Approach after Tingvall and Haworth (1999) and the Swedish Road Administration (2006) established that there is an ethical basis for prioritizing safety above all else. This ethical mandate has served as the foundation for speed management activities intended to prevent all deaths and serious injuries on various countries' roadways. An important demonstration of this Safe System based approach to speed management is that implemented in Auckland, New Zealand. In 2016, the Waka Kotahi New Zealand Transportation Agency published the *New Zealand Speed Management Guide.* This guide created a framework for implementing target speeds and demonstrated the benefit that can be achieved through unified action under a Safe System vision. The guide also heavily influenced the steps laid out in this informational report.

➔ See Appendix A.8. to see how Auckland implemented New Zealand's influential Speed Management Guide.

2.6.1. Overview of Speed Management Practices

Speed management is, generally, an approach to meeting safe speeds. Speed management may entail changes to speed limits, changes to roadway designs (e.g., intentionally designing narrower lanes on a roadway to slow traffic), use of traffic control to maintain desired speeds, and the use of enforcement, signs, and technology to increase compliance with speed limits and to provide feedback to drivers about desirable operating speeds. When selecting appropriate speed management techniques, it may be helpful to consider the roadway setting, purpose of the roadway, traffic composition, and desired pedestrian and bicyclist activity, alongside budgetary constraints (FHWA 2017a). Readers are encouraged to visit FHWA's Speed Management Safety webpage to access additional resources for selecting and implementing different speed management countermeasures (FHWA 2017b). FHWA and ITE (2017) developed a *Traffic Calming ePrimer* that contains a module entitled "Toolbox of Individual Traffic Calming Measures." This module provides guidance on implementing traffic calming treatments, including the following:

- Lateral shifts
- Chicanes
- Realigned intersections
- Traffic circles
- Roundabouts
- Speed humps
- Speed cushions
- Speed tables
- Raised crosswalks
- Raised intersections
- Corner extensions/bulb-outs
- Chokers
- Median islands
- On-street parking
- Road diets
- Diagonal diverters
- Road closures
- Median barriers and forced-turn islands

The FHWA has also published a report titled *Noteworthy Speed Management Practices* (Hawkins and Hallmark 2020). In this report, Hawkins and Hallmark highlight exemplary speed management approaches and the various elements they combined. Some critical practices for successful speed management programs include the following:

- It is valuable to develop a speed management program integrated with a vision for public health (e.g., Vision Zero).
- It is valuable to set indicators of success and collect relevant data.
- Speed limits should be credible and should align with the roadway context.
- Countermeasures can be combined to produce comprehensive speed management.

2.6.2. Traffic Safety Management and Analytical Frameworks

Many roadway agencies in the United States use a six-step traffic safety management process to identify locations for treatment to improve safety. A variation of this approach, called the systemic safety approach, is compatible with the Safe System Approach. The systemic safety approach follows six steps, including the following (Preston, Storm, Bennett, and Wemple 2013):

1. Identify focus crash types and risk factors.
2. Screen and prioritize candidate locations.
3. Select countermeasures.
4. Prioritize projects.
5. Identify funding for systemic program and implement.
6. Perform system program evaluation.

Some traffic safety agencies have also implemented systemic approaches to speed management. These approaches include reviewing and implementing speed limits over areas rather than just on one or two roads at a time. European area-wide road safety management programs have shown significant crash and injury reductions ranging from 15 to 80 percent (WHO 2004). Eventually, the aim should be to have all speed limits on every road within the network aligned to the same speed management framework. By treating the entire network, agencies can achieve the greatest reduction in fatalities and serious injuries. Additionally, inconsistent application of Safe System-aligned speeds and roadway designs may lead to road user confusion.

Internationally, agencies have more explicitly tied the Safe System Approach to speed management practices. For example, Jurewicz (2009) explicitly envisions a Safe System analysis as a key decision point for determining which speed management techniques are needed to achieve a “harm minimization speed” (or a “target speed” in the U.S. context). In this framework, agencies follow a four-step process for speed limit setting within a Safe System Approach:

- First, the agency determines what the posted speed limit of a roadway should be based on its functional purpose.
- Second, the target speed that may be appropriate for the functional classification and posted speed limit are identified.

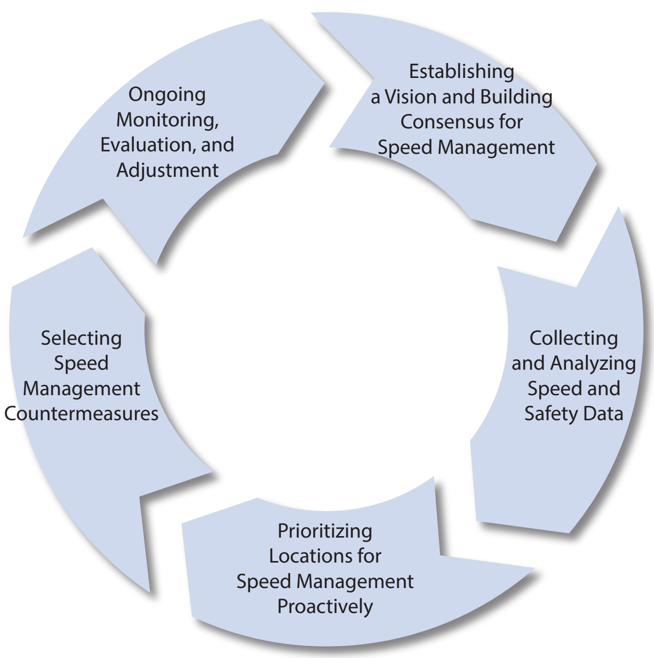
- Following this step, the agency analyzes the roadway using Safe System Approach principles to determine whether the current roadway design facilitates the target speed of the roadway.
- Finally, the agency selects speed management measures to align the roadway design with the target speed (Jurewicz 2009).

One analytical framework used by some Safe System practitioners to align roadway design with target speed is the concept of “Movement and Place.” Movement refers to the mobility provided to different modes of travel at a location, and place refers to the activity level desired at a location. High “place” areas have a high level of VRU activity and are key destinations for people. Corben (2020) emphasizes that the injury minimization speed for pedestrians and bicyclists is 19 mph, so target speeds in high “place” areas should be based on this threshold. Examples include central city zones and major (commercial) activity centers. “Movement” is a function of road hierarchy and the traffic demand for a route. Many high-risk routes within cities are a result of a conflict between a medium to high place function and medium to high movement functions. These are often referred to as mixed-use arterials (Corben 2020).

The Movement and Place framework is similar to, but differs from, the concepts of mobility and access often used in determining the function of roadways in the United States. International agencies have applied the Movement and Place framework as an analytical lens for identifying risks within a roadway network that then can be treated proactively. Considering the feasibility of a location to serve as a place allows practitioners to frame roadway design in terms of who could use a location safely and comfortably. As the movement afforded by a location increases, its capacity to serve as a place typically decreases, but this is not a linear relationship (Corben 2020).

3. THE SAFE SYSTEM APPROACH FOR SPEED MANAGEMENT

Speed is directly linked to the severity of traffic crashes. Given the high incidence of speeding-related fatalities in the United States, and the strategic emphasis on speed management in the NRSS, a new, Safe System-based approach to speed management may support agencies' efforts to prevent traffic fatalities and serious injuries by proactively producing target speeds on the roadway network. This chapter outlines a new Safe System Approach for Speed Management framework. The proposed framework (**Figure 3**) is a high-level process that has been constructed from a range of different case studies and informed by the research literature cited throughout Chapter 2; readers are encouraged to read the case studies presented in the Appendix to see specific applications of concepts and principles. Subsections in this chapter correspond to each of the five stages of the framework shown in **Figure 3**. While these stages are presented here as a cyclical process, agencies may be at different stages of implementation and may need to revisit earlier or later stages of the process as they evaluate their speed and safety outcomes. This framework is also intended to encompass actions taken by both State and local agencies, but the specific countermeasures and coalition building jurisdictions use to achieve target speeds may vary.



Source: FHWA.

Figure 3. The Safe System Approach for Speed Management Framework.

Establishing a Vision and Building Consensus for Speed Management

This section introduces topics relevant to transportation agencies seeking to establish a new Safe System-based speed management program. These topics include examining institutional mechanisms, leveraging community support, embedding the Safe System Approach into organizational policies and plans, and adopting a strategic framework.

A key idea discussed throughout this section is the identification and understanding of potential policy barriers, various methods to compensate or overcome these barriers, as well as institutional mechanisms for implementation. This section contains discussion of speed management strategies for agencies that can easily change speed limits as well as those that cannot. The following case studies also demonstrate how agencies can establish a vision and build consensus for speed management:

- Case Study A.1. Washington State Injury Minimization and Speed Management—Washington State, USA
- Case Study A.3. 2020 Vision Zero: Speed Management—Fremont, California, USA
- Case Study A.6. Multi-disciplinary Approach for Speed Reduction Citywide—Portland, Oregon, USA

Collecting and Analyzing Speed and Safety Data

This section lists the different types of data that can be used to identify speed problems on a network. It also discusses the different types of data and their sources and limitations. The Safe System Approach for Speed Management framework should be a data-informed approach that can leverage clear information to help enforce the vision for speed management while also supporting ongoing evaluation efforts, especially if interim goals are set on the way to achieving target speeds.

Relevant case studies for this topic include the following:

- Case Study A.2. Video-Based Network-Wide Speed and Speeding Analysis—Bellevue, Washington, USA
- Case StudyA.7. Seattle Systemic Speed Limit Reduction—Seattle, Washington, USA

Prioritizing Locations for Speed Management Proactively

This section describes the process of applying different methods for identifying treatment locations. These methods include systemic analyses, a placemaking framework, and equity considerations. The Safe System Approach for Speed Management framework recognizes that sometimes the entire network cannot be targeted simultaneously, meaning that areas within the network must be prioritized over others. Agencies may consider employing *Highway Safety Manual (HSM)* (AASHTO 2010) methods for using crash data to apply safety performance functions and Empirical Bayes adjustments for determining estimated crashes in a systemic process. This will enable agencies to proactively identify locations where the risk of a serious or fatal crash is high (Preston, Storm, Bennett, and Wemple 2013). It may be beneficial to target specific segments with major speed problems or where fatal and injury crashes can be most reduced first while building support for more widespread systemic improvements.

Relevant case studies for this topic include the following:

- Case Study A.6. Multi-Disciplinary Approach for Speed Reduction Citywide—Portland, Oregon, USA
- Case Study A.9. Network-Wide Speed Limit Reduction—Mornington Peninsula, Australia

Selecting Speed Management Countermeasures

This section includes the different approaches agencies take to treating speed problems at the locations identified in the previous step while moving toward systemic achievement of target speeds. Implementation in a Safe System Approach for Speed Management framework includes both infrastructure changes and speed limit changes (where possible). Speed limit changes can be controversial, but other countermeasures, including traffic calming and feedback signs, can reduce operating speeds, making them closer to target speeds while agencies build support for lowering speed limits. It is important to adequately consider which kinds of roads will require supporting infrastructure and when speed management projects can be implemented in relation to speed limits.

Relevant case studies for this topic include the following:

- Case Study A.5. New York City's Speeding Solutions Toolkit—New York City, New York, USA
- Case Study A.10. Speed Limit Reduction on Urban Roads—Republic of Korea

Ongoing Monitoring, Evaluation, and Adjustment

The final section of the Safe System Approach for Speed Management framework refers to the many interrelated steps that can be taken to move operating speeds on a roadway network closer to target speeds. Monitoring helps inform better decision making for future speed limit programs and helps to determine locations where additional interventions may be required to achieve target speeds. This includes locations that require additional enforcement, infrastructure, or other supporting initiatives. The results also help communicate to the public why speed management programs are being undertaken and dispel some of the myths surrounding them.

Relevant case studies include the following:

- Case Study A.4. Automated Speed Enforcement—Montgomery County, Maryland, USA

3.1. Establishing a Vision and Building Consensus for Speed Management

Although speed management programs have the potential to substantially improve safety for all road users, speed management activities are often polarizing and may entail publicly perceived compromises in vehicular throughput or mobility. Therefore, the first step in developing an effective, Safe System Approach-based speed management program is to create community support in a jurisdictional vision for target speeds. Creating this vision may entail multiple steps, including the following:

1. Examining the existing legal constraints and sociopolitical factors in your jurisdiction.
2. Determining the practical scope of speed management activities.
3. Identifying appropriate speed management activities for your agency.

This section presents information for both State and local agencies. The relationships between State, county, and city DOTs vary from State to State, so not all speed management activities highlighted may be possible for all agencies. As mentioned, this section presents potential steps for agencies able to set lower speed limits as well as those for whom speed limit setting is regulated legislatively.

3.1.1. Examine the Existing Legal Constraints and Sociopolitical Factors in Your Jurisdiction

Agencies seeking to create a vision for a Safe System-based speed management program may start with a thorough understanding of the current speed limit laws that govern posted and statutory speed limits in their jurisdictions. City agencies may also need to examine ownership of the local road network to determine which roads are within their jurisdiction and would therefore be candidates for a speed management program. State DOTs may have more flexibility for changing posted speed limits, but governing legislation varies from State to State.

State and local ordinances for road design and signing may impact the process of changing speed limits. Statutory speed limit changes require legislative action and are therefore beyond the scope of this report. However, State DOTs can adopt policies that can influence the ways in which local agencies design roads and post speed limits. For example, changes to local policies and ordinances may enable local agencies to implement road diets or otherwise modify locally owned roads to align operating speeds closely with target speeds.

In the *Washington State Injury Minimization and Speed Management Policy Elements and Implementation Recommendations*, the authors draw attention to the fact that local agencies may be bound by their local code to follow the International Fire Code (IFC) and require a 28-ft street with parking on both sides. This type of roadway may provide minimal visual friction and could induce higher operating speeds, so local agencies may need exemptions to local codes to avoid designing these types of roadways. Policies providing these kinds of exemptions could be part of a speed management program (Washington Injury Minimization and Speed Management Policy and Guidelines Workgroup 2020).

3.1.2. Determining the Practical Scope of Speed Management Activities

After identifying important factors that influence the ability to adjust speed limits within a jurisdiction, the next step is to consider the practical scope and extent of possible speed management programs. If speed limits can be changed, it may be helpful to:

- Identify applicable road segments for speed limit change.
- Identify appropriate target speeds for roadway designs.

Identify applicable road segments for speed limit change: When determining where speed limits can be changed, agencies should seek to answer several related questions:

- Who owns this roadway?
- What speed limit is posted on this roadway?
- Where are speed limit signs located on this roadway?
- Are there any applications for slow-speed zones on this roadway?
- What design features may need to be changed to accommodate a speed limit change?

Considering these questions beforehand may aid with subsequent stages of the Safe System Approach for Speed Management framework, namely the "prioritizing locations" step to identify sites for treatment. Jurisdictions will see the greatest safety benefits if all roads within a network are aligned with that jurisdiction's speed management goals (WHO 2004), but some agencies may need to prioritize specific roadways first to build public support for using target speeds on all roads under the agency's jurisdiction. Some agencies may have limited potential to make changes on State owned roadways within their jurisdiction, for example, so focusing on locally owned arterials at this stage may simplify the prioritization process later. Identifying applicable slow-speed zone locations may also aid in prioritization later.

Urban cores and school zones are often the most applicable locations in the United States for the implementations of wide-scale speed management efforts (see Sharpin et al. 2021 for some common applications), but some cities have also found success implementing shared streets programs in other contexts. These programs—sometimes called "partial street closures", "healthy streets", "play streets", "bike boulevards", and "neighborhood greenways"—can include a variety of different countermeasures and geometric designs but typically entail community outreach and often feature intensive traffic calming treatments. Agencies seeking to apply lessons learned from shared streets programs may find success by installing new pedestrian and bicycle facilities (often through road diets to reconfigure existing travel lanes), combining partial street closures with traffic calming devices, reallocating on-street parking as curb space, and reducing speed limits to make roadways safer for VRUs (Combs and Pardo 2021; Combs et al. 2020).

Highlighting successfully implemented slow-speed zones can be a first step to demonstrating the efficacy of Safe System-based speed management efforts. Successes with slow-speed zones can build public support for more projects while demonstrating that the implementing agency is directly improving the safety of all road users. These early successes can help build motivation for broader systemic speed management programs.

Identify appropriate target speeds for roadway designs: The goal of the Safe System Approach for Speed Management framework is to enable agencies to match operating speeds with target speeds along corridors to prevent fatalities and serious injuries. To the extent possible, attaining target speeds on a roadway should be considered the end goal of speed limit adjustments. However, drivers may not immediately respond to changes in speed limit, especially if corresponding infrastructure designs are not also implemented. Therefore, it may be necessary to implement roadway redesigns and adjust speed limits incrementally while measuring changes in mean speeds and building public support for the target speeds. It may also be necessary to adjust target speeds if ongoing data collection reveals that safety goals (e.g., prevention of fatal crashes) have not yet been met, or if safety problems have migrated to different locations along a corridor or network.

There are a variety of resources available that may assist agencies in identifying target speeds. One method that agencies can use is to base target speeds on driver speeds that correspond to a low (i.e., 10 percent or less) chance of a fatal or serious injury occurring. To apply this method, agencies may identify target crash types for prevention as part of a strategic program (see the discussion of Highway Safety Improvement Plans in Section 3.1.3) and then implement speed management countermeasures to reduce the speeds that produce fatal or serious injuries in those crash types. See **Table 5** for example crash types, driver speeds, and target speeds. For crash types involving two vehicles, the mass and speed of each vehicle is assumed to be identical (Jurewicz, Sobhani, Woolley, Dutschke, and Corben 2016; Doecke, Kloeden, Dutschke, and Baldock 2018).

Table 5. Probability of fatality or serious injury corresponding to different crash types.

Crash Type	Driver Speeds Corresponding to 10% Fatal Injury Risk and 10% Serious Injury Risk
Pedestrian/vehicle crash[i]	20 mph for fatality 10 mph for serious injury
Side impact vehicle/vehicle crash (typically at intersections)[i]	30 mph for fatality 20 mph for serious injury
Head-on vehicle/vehicle crash (typically without median barriers)[i]	30–45 mph for fatality 20 mph for serious injury
Rear-end vehicle/vehicle crash[i]	35–70 mph for fatality 35 mph for serious injury
Motorcycle crash[ii]	19 mph for fatality

i = synthesized by Washington Injury Minimization and Speed Management Policy and Guidelines Workgroup, 2020.

ii = reported as biomechanical tolerance in Gaca and Pazdan 2017; see also Fildes, Langford, Andrea, and Scully 2005.

Another target speed method adopted by some State DOTs is to specify the highest speed at which drivers should operate on a road based on the roadway context, multimodal traffic generated by adjacent development, and potential risks to VRUs. These agencies then set design speeds as close to those target speeds as feasible. For example, Florida DOT (FDOT) lists target speeds in its Roadway Design Manual for different context classifications, as well as speed management techniques that can be used in retrofits or new designs to achieve those target speeds (**Table 6**) (FDOT 2022). The Florida design manual provides target speeds ranging from less than 25 mph to 45 mph on roads in rural towns, dependent on design features; if the desired safe operating speed in a rural town is 40 mph, the design manual states that agencies may consider installing roundabouts, lane narrowing, and more (FDOT 2022). FDOT recognizes that target speeds are highly context-sensitive and may require incremental changes to roadway design and speed limits to achieve results. However, the exemplified speed management strategies demonstrate that establishing target speeds is an important step to determining the most appropriate design features to ensure safe operations on a road.

Table 6. FDOT Design Manual target speeds and speed management techniques.

Area Type	Context Classification	Target Speed (mph)	Strategies
Rural	C1-Natural (natural or wilderness lands)	55–70	N/A: Speed Management Strategies are not used on high-speed roadways
Rural	C2-Rural sparsely settled)	55–70	N/A: Speed Management Strategies are not used on high-speed roadways
Rural	C2T-Rural Town (small concentrations of developed areas surround by natural areas)	40–45	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, Rectangular Rapid Flashing Beacons (RRFB) and Pedestrian Hybrid Beacons (PHB)
		35	Techniques for 40–45 mph, plus On- street Parking, Street Trees, Short Blocks, Islands at Crossings, Road Diet, Bulb-outs,Terminated Vista
		30	Techniques for 35–45 mph, plus Chicanes, Islands in curved sections
		≤ 25	Techniques for 30–45 mph, plus Vertical Deflection
Suburban	C3R-Suburban (mostly residential within large blocks), C3C-Suburban Commercial (mostly non-residential with large building footprints)	50–55	Project-specific
		40–45	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, RRFB and PHB
		35	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, Islands in crossings, Road Diet, RRFB and PHB, Terminated Vista
Urban	C4-Urban general (mixed uses within small blocks)	40–45	Roundabout, Lane Narrowing, Horizontal Deflection, Speed Feedback Signs, RRFB and PHB
		35	Techniques for 40–45 mph plus On-Street Parking, Street Trees, Short Blocks, Islands at Crossings, Bulb-outs, Terminated Vista, Road Diet
		30	Techniques for 35–45 mph plus Chicanes, Islands in Curve Sections

Table 6. FDOT Design Manual target speeds and speed management techniques. (continued)

Area Type	Context Classification	Target Speed (mph)	Strategies
Urban	C5-Urban Center (missed uses within small blocks, typically concentrated around a few blocks)	35	Roundabout, On-street Parking, Street Trees, Short Blocks, Speed Feedback Signs, Islands in Crossings, Road Diet, Bulb-outs, RRFB and HAWK, Terminated Vista
		30	Techniques for 35 mph plus Chicanes, Island in Curve Sections
		25	Techniques for 30–35 mph plus Vertical Deflection
Urban	C6-Urban Core (areas with highest density)	30	Roundabout, On-Street Parking, Horizontal Deflection, Street Trees, Islands in Curve Sections, Road Diet, Bulb-outs, Terminated Vista
		25	Techniques for 30 mph plus vertical deflection

Source: FDOT. (2022). FDOT Design Manual: Development and Processes. Tallahassee, FL: Florida Department of Transportation.

Regardless of whether an agency has the capacity to change speed limits, a Safe System Approach for Speed Management framework could include roadway modifications and traffic calming efforts. Although lowering speed limits may be effective at reducing mean speeds (see **Table 4** in Chapter 2), speed limit changes alone are unlikely to produce target speeds. Therefore, agencies seeking to achieve target speeds through a Safe System Approach should consider prioritizing the roadway modification components of a speed management program while also lowering speed limits.

3.1.3. Establishing a Vision for Speed Management: Mechanisms for State Agencies

State DOTs and other State-level traffic safety stakeholders (including legislative bodies) are well-positioned to meaningfully shape a vision for speed management through unique levers, including the following:

- State transportation policies or Executive Orders
- Strategic plans
- Roadway design manuals

Not every State agency has access to all potential measures that can be implemented through a speed management program, so agencies seeking to adopt the Safe System Approach for Speed Management framework are encouraged to review and identify potential barriers and legal constraints to different approaches to determine which of the levers can be used.

State Transportation Policies or Executive Orders

Where permissible, State agencies can adopt design or project prioritization policies that align with the Safe System Approach to provide recommendations to other departments of transportation (e.g., county DOTs or city DOTs) on how best to improve safety and to provide flexibility for those lower-level agencies to deal with specific concerns in their jurisdictions. Two examples of State policies that can be used to create a statewide vision of speed management include California's Complete Streets Policy and Washington State's Injury Minimization and Speed Management Policy.

California's Complete Streets Policy. Thirty-five States and over 1,500 other jurisdictions in the United States have adopted a Complete Streets policy (Smart Growth America 2022). According to FHWA's report to Congress, *Moving to a Complete Streets Design Model: A Report to Congress on Opportunities and Challenges*, a Complete Street is "safe, and feels safe, for everyone using the street" (FHWA 2022a). The report notes that Complete Streets embody both the safe roads and safe speeds elements of the Safe System Approach, and one of the major areas of emphasis in the report is the need to "make Complete Streets FHWA's default approach for funding and designing non-access-controlled roadways" (FHWA 2022a). This emphasis area entails multiple considerations for funding and guidance—one of which involves encouraging State DOTs to update design manuals to facilitate designing for lower-speed roadways—to help make Complete Streets designs the easiest option for stakeholders for all non-access-controlled roadways (FHWA 2022a).

Therefore, the adoption of a Complete Streets policy is a viable mechanism for State DOTs to create statewide visions for speed management. One DOT that has embraced this vision is California. In 2021, Caltrans passed its Complete Streets policy, directing that "in locations with current and/or future pedestrian, bicycle, or transit needs, all transportation projects funded or overseen by Caltrans will provide comfortable, convenient, and connected complete streets facilities for people walking, biking, and taking transit or passenger rail unless an exception is document[ed] and approved." (Caltrans 2021). Speed management is an intrinsic component of roadway design that meets the needs of all ages and abilities, and the intent of California's Complete Streets policy is to provide design flexibility so that local practitioners can make use of "national and international best practices related to traffic calming, speed reduction, universal design, and roadway design to increase user safety and comfort." The policy even notes that flexibility is essential to prioritizing safety above other transportation goals (Caltrans 2021), so providing design flexibility through a statewide Complete Streets policy is a viable pathway to pursuing a Safe System Approach for Speed Management.

Washington State's Injury Minimization and Speed Management Policy. Although Washington State's working group recommendations for speed management provide many applicable suggestions for meeting target speeds, one element that helps create a statewide vision is centered on funding structures. In the *Injury Minimization and Speed Management Policy*, the working group recommends the creation of "competitive grant programs… to make injury minimization and speed management practices eligible for funding" and to "add injury minimization consideration in the selection criteria" (Washington Injury Minimization and Speed Management Policy and Guidelines Workgroup 2020).

Washington State DOT followed through on this recommendation and modified the prioritization practices for the Safe Routes to School program and the Pedestrian and Bicycle program. Relevant changes include an emphasis on projects where there are higher operating speeds (greater than 25 mph) or known speeding problems and on those with quality plans for implementing speed management techniques to lower speeds. By changing this prioritization mechanism, the State is now more likely to prioritize and fund projects that directly lower speeds and improve safety. These changes also make speed management projects more competitive for limited roadway improvement funds. By simply changing the application process, Washington State has effectively shifted roadway project prioritization toward a Safe System-aligned vision.

➔ **For more information on Washington State's prioritization program that set a statewide vision for safe speeds, see Appendix A.1.**

Strategic Plans

States receive Federal funding for the Highway Safety Improvement Program (HSIP), whose purpose is to achieve a significant reduction in traffic fatalities and serious injuries on all public roads, including non-State-owned public roads and roads on Tribal land (23 U.S.C. 148(b)). To obligate HSIP funds, States must develop and update their Strategic Highway Safety Plans (SHSPs) (23 U.S.C. 148(c)(1)(a)). States must also set safety performance targets pursuant to 23 U.S.C. 150(d). These safety performance targets include the following: number of fatalities, rate of fatalities, number of serious injuries, rate of serious injuries, and number of non-motorized fatalities and non-motorized serious injuries (23 CFR 490.207(a)).

The SHSP is a useful tool for framing State safety concerns, and State DOTs frequently cite speeding as an emphasis area within their SHSPs. However, Finkel et al. recommend that, to better align SHSPs with the Safe System Approach, State DOTs should refocus the speeding emphasis area on speed management rather than relying on education and enforcement only (Finkel, McCormick, Mitman, Abel, and Clark 2020). Emphasizing speed management as the key to addressing speed problems at the State level may enable State agencies to create a unified vision for meeting target speeds while also directing HSIP funds toward addressing the roadway design problems that produce unsafe speeds.

In addition, the Infrastructure Investment and Jobs Act (IIJA) (Pub. L. No. 117-58, also known as the "Bipartisan Infrastructure Law" (BIL)) created a new Vulnerable Road User (VRU) Safety Special Rule (23 U.S.C. 148(g)(3)) requiring States to dedicate 15 percent or more of HSIP funding to safety projects that address VRU safety if total annual VRU fatalities represent 15 percent or more of the State's total annual crash fatalities. VRU projects provide State DOTs an opportunity to advance Safe System Approach-oriented countermeasures and speed management techniques by addressing limitations in existing right-of-way (FHWA Office of Safety 2022).

Roadway Design Manuals

A third mechanism States can use to create a vision for speed management is to set target speed ranges for roadway contexts and classifications in their design manuals. Many State DOTs and local agencies rely on roadway design manuals for selecting design speeds and geometric design configurations for roadways of different functional classifications and contexts. Historically, these design speeds have had a flexible relationship to posted speed limits and may facilitate higher operating speeds than desired for safety performance (see Section 2.3 for more information). The land use context for specific roadways can also change over time. A roadway designed for a specific function and speed may no longer match its context after a period of time. An example scenario for this could be a minor arterial designed to provide mobility with a design speed equal to 55 mph and a posted speed limit of 45 mph in a suburban area. If the land adjacent to this roadway gets developed over time to provide access to housing and commercial lots, the existing design speed and posted speed limit may no longer be consistent with safety performance goals for all modes of travel.

A mismatch between current land use and roadway design can serve as a motivation for setting target speeds below the posted speed limit and considering which combinations of traffic calming devices or roadway design changes can be reasonably implemented to bring operating speeds closer to target speeds based on roadway context. For the previously described example of a roadway adjacent to housing, the roadway owner may implement a road diet, repurposing some of the right-of-way width to narrow the roadway or to add bicycle lanes and sidewalks.

3.1.4. Establishing a Vision for Speed Management: Mechanisms for Local Agencies

Local agencies like city DOTs and metropolitan planning organizations (MPOs) also have pathways for creating visions for speed management. A mechanism by which local agencies may establish a vision for speed management is by adopting Vision Zero plans. In fact, most early adoptees of Vision Zero in the United States were local agencies trying to deal with local roadway problems and to unite stakeholders around a unifying vision of zero traffic deaths and serious injuries.

As with State agencies, local agencies can vary significantly in their ability to pursue different speed management projects. In some States, cities may own few of the roadways within their jurisdictions, and in others, there may be limited capacity for local speed limit setting. Local practitioners are encouraged to investigate their legal and policy barriers to determine the extent to which programs like Slow Streets (i.e., programs of partially closing streets and installing traffic calming devices, often throughout a residential network, to create slow-speed zones) or Vision Zero can be implemented (Glandorf 2020).

Adopt an Organizing Approach to Planning like Vision Zero

Vision Zero is a strategic goal of preventing all death and serious injury within a jurisdiction. It was born out of an ethical concern about traffic deaths in Sweden in 1990s before gaining traction in the United States in the mid-2010s (Dumbaugh et al. 2019). The Safe System Approach emerged from the principles of Vision Zero first espoused by Tingvall and Haworth (1999) and is often seen as the basis or framework for achieving Vision Zero (Johns Hopkins University, ITE, and the FIA Foundation 2021). As such, the development of Vision Zero plans has been an effective method for local staff to build a coalition around the effort to improve traffic safety and create a vision for speed management by emphasizing the effect of speed on fatalities and serious injuries, particularly for VRUs. According to the Vision Zero Network, a political commitment to Vision Zero "should include passage of a local policy laying out goals, timeline, stakeholders, and a commitment to community engagement, transparency, and equitable outcomes" (Vision Zero Network N.D.). This commitment can then enable multidisciplinary leadership to develop a Vision Zero plan. According to LaJeunesse, Naumann, Sandt, Spade, and Evenson (2020), effective Vision Zero plans typically build upon clear safety goals and objectives, identify specific agency actions to meet those goals and objectives, specify performance measures for validating the agency actions, and designate lead and supporting agencies for accomplishing those actions. A clear Vision Zero plan can unite safety stakeholders within a city under a goal of speed management, as shown by the example in **Table 7**.

➔ See Appendix A.3. to see how Fremont, CA used Vision Zero to create a unified goal around traffic safety that produced a 44 percent decrease in crashes involving speeding.

Additional framing visions for uniting diverse, multidisciplinary stakeholders include Slow Streets or Complete Streets programs. See Section 3.1.2 and Section 3.1.3 for more information on how Slow Streets and Complete Streets policies and programs can be used to promote speed management in your jurisdiction.

Table 7. Components of a Vision Zero plan that addresses speed.

Safe Systems Principle: Manage Kinetic Energy Transfer Among Road Users	
Goal	Traffic speeds in the city are consistent with public health goals.
Objectives	By the end of 2022, city staff will have developed street classification standards for designing streets with operating speeds of no more than 20 mph on local roads, 30 mph on collector roads, 35 mph on arterial roads, and 45 mph on highways. By the end of 2026, city staff will have implemented road diets on 50 percent of roadways where such treatments are appropriate (e.g., roadway segments with more than two vehicle travel lanes and traffic volumes < 20,000 annual average daily traffic).
Agency Actions	Starting in 2021, city staff will develop a roadway classification scheme designed to provide all road users with safe mobility and access to key destinations. Starting in 2021, city staff will screen the roadway network for locations suitable for road dieting.
Performance Measures	Online publication of an updated street classification standard indicating design speeds by roadway type and a public forum for public input on design speeds. Percentage of roadways that have undergone road diet lane reconfigurations.
Lead Agency	Engineering department.
Supporting Agencies and Entities	Planning department, public health department, business owners, and local stakeholders.

Source: LaJeunesse, S., Naumann, R. B., Sandt, L., Spade, C., and Evenson, K. R. (2020). Guide to Developing a Vision Zero Plan. Chapel Hill, NC: Collaborative Sciences Center for Road Safety.

3.1.5. Examples of Establishing a Vision and Building Consensus for Speed Management

If an agency seeks to move towards achieving the desired target speeds for minimizing crash injuries shown in **Table 5**, case studies in the Appendix provide information about the activities that can be conducted at this stage of the Safe System Approach for Speed Management framework. As an example, the City of Portland set a unifying goal with a Vision Zero commitment, determined design elements that could be used to achieve target speeds, and used local policy to implement those design elements.

As discussed in Case Study A.6., the City of Portland, through its Portland Bureau of Transportation (PBOT) adopted Vision Zero in 2015 and released an action plan to coordinate traffic safety efforts toward Vision Zero in 2016 (PBOT 2016). This action plan presented numerous statistics about crashes and injuries in Portland, but it also presented humanizing testimonies about individuals killed in the city in motor vehicle crashes, leveraging this emotional appeal alongside a careful examination of crash causation to make the case for Vision Zero efforts, especially speed management. The action plan discusses the impacts of speed on traffic safety in detail and makes the case for injury minimization speeds. The plan also identifies multiple actions, both immediate and long term, for addressing speed. Prominently listed are roadway modifications, like narrower lanes, on-street parking, street trees, and more. This Vision Zero Action Plan served as the springboard for other elements discussed in Case Study A.6 and shows how this vision framing serves as an important first stage in the Safe System for Speed Management framework (PBOT 2016).

However, the City of Portland did not merely cast a vision for safe speeds; in the same year the city released the Vision Zero Action Plan, it released a memorandum on a proposed speed zone methodology. This methodology proposes a simplified speed limit matrix (**Figure 13**) that identifies both ideal speed limits based on traffic composition and traffic calming features needed to achieve safe speeds. For example, on roadways where bicycle traffic is desired, if the posted speed limit is 40 mph, PBOT recommends the use of a permeable barrier to separate bicyclists from potentially unsafe vehicle speeds. On streets with speed limits set at 20 mph (the injury minimization speed shown for pedestrians in **Table 5**) or higher, sidewalks and other forms of separation are recommended (PBOT 2016). These treatments both separate pedestrians from unsafe speeds and may also create visual friction to help slow vehicles down and achieve target speeds equal to the posted speed limits. The road reconstruction efforts following these Vision Zero efforts have produced numerous speed benefits, including new target speeds on different streets.

An agency seeking to use the Safe System Approach for Speed Management framework does not need to follow the exact steps taken by Portland to move from a Vision Zero plan to target speed identification, but this framework of building public and official support and then identifying roadway designs that leverage that support may be a successful approach. For example, if an agency wants to prevent pedestrian fatalities on streets in the urban core, they may do the following:

- Publish relevant communications about the safety of pedestrians in relation to roadway speeds.
- Identify roadways where operating speeds are in excess of target speeds.
- Identify relevant roadway modifications to achieve those target speeds (e.g., bulb-outs or street trees in **Table 6**).
- Change internal policies to make these traffic calming features required parts of new projects.
- Identify roadways to redesign as part of Vision Zero efforts.

➔ **See Appendix A.6. for more information on the City of Portland's process.**

3.2. Collecting and Analyzing Speed and Safety Data

3.2.1. Using a Data-Informed Approach

To dispel myths and combat negative perceptions of speed limit reductions, it is crucial to use quality data to inform every step of the speed management process. First, information regarding the existing network should be gathered and combined to get an assessment of the existing level of safety performance on the road network. Data collection provides a secondary benefit, namely earning public buy-in to the vision for speed management. Providing information to the public regarding the benefits of speed management is important. An open and transparent approach to data collection and speed management, especially a public education campaign that informs community members about the benefits of target speeds, is beneficial for the success of a program. Key pieces of information that can win support for the speed management program include expected reductions in death and serious injury crashes and explanations of the decision-making process for determining target speeds. This will communicate why a speed management approach was chosen over other safety treatments, such as wide-ranging infrastructure improvement projects.

3.2.2. Relevant Data for a Speed Management Program

Agencies routinely collect data relevant to a speed management program when performing engineering speed studies (see Section 2.2). All of the speed-related data listed by Forbes, Gardner, McGee, and Srinivasan (2012) are relevant, but an expanded list of data types often used to model systemic safety include the following (Thomas et al. 2018; Preston et al. 2013; City of Baltimore 2021; Montgomery County Planning Department 2022):

- Roadway data
    - Facility type
    - Number of lanes and lane widths
    - Shoulder type and shoulder widths
    - Road edge condition (e.g., presence of side slop or drop off)
    - Access point density
    - Superelevation (a measure of the tilt or bank or a road’s profile)
    - Curvature (horizontal and vertical)
    - Number of legs (for intersections)
    - Skew angle (at intersections)
    - Pedestrian, bicyclist, and rail crossings (number and type)
    - On-street parking
    - Sidewalks and bicycle facilities
    - Accessible ramps and other ADA-facilities
    - Transit facilities

- Traffic volumes
  - Vehicular annual average daily traffic (AADT)
  - Turning movements
  - Vehicle composition (especially types of heavy vehicles)
  - Number of pedestrians
  - Number of bicyclists
  - Number of micromobility users
- Speed data
  - Posted speed limits
  - Operating speeds
- Traffic control type and location
  - Additional pedestrian or bicycle intervals
  - Turning phases
- Lighting facilities and location
- Crash history
  - Fatal and injury crashes
  - Speeding-related crashes
- Other contextual data
  - Transit stops
  - Adjacent development types
  - Points of interest (e.g., schools)
- Equity emphasis area indicators and metrics

Although collecting these data for an entire network may be time and resource intensive, doing so will enable analysts to thoroughly identify at-risk sites in need of treatment. Agencies often use these data on a network basis to build safety performance functions and other crash models that can be used to calculate predicted and expected crashes based on road use context and traffic volumes in accordance with the *HSM* (AASHTO, 2010).

Because the intent of a Safe System Approach for Speed Management framework is to prevent fatal and serious injury crashes, these crash types may be considered the focus crashes for modeling efforts. Agencies may examine crash histories and crash prediction models to determine locations where fatal and injury crashes are overrepresented compared to expected values. These locations can then be cross referenced to locations where speed limits or operating speeds are more than the desired target speeds. This comparison will then inform the process of project prioritization. Although speeding is not the key focus of this framework, speeding-related crashes may provide additional context to identify locations with speed-related safety problems.

➔ **See Appendix A.7 to learn how Seattle DOT examined speed limit and traffic-volume data to identify locations for treatment as part of its speed management program.**

Another key factor is traffic composition. Section 2.4 addressed the relationship between vehicle mass, kinetic energy, and crash severity. One consideration for agencies implementing a Safe System Approach for Speed Management framework is to examine traffic composition and to identify routes where heavy vehicles are common; even if operating speeds at these locations match target speeds, heavy vehicles may increase the net kinetic energy of a crash and create additional risk of death or serious injury. Heavy vehicle routes may also be considered during project prioritization.

3.2.3. Quality Data Are Key

Speed has been cited by researchers as one of the most desired and needed data types for safety analyses, but researchers often rely on surrogate data, such as speed limit data, to estimate the operating speeds or impact speeds of vehicles involved in crashes (Nordback et al. 2019).

Even existing Safe System Approach methods, like the *FHWA Safe System-Based Framework and Analytical Methodology for Assessing Intersections* (SSI) typically rely on assumptions of operating speed to predict crash severity (Porter et al. 2021).

While newer methods of collecting speed data—such as from probe vehicles and connected vehicles—are available, these data sources are not without their own limitations. These data sets are collected by private corporations and are available to agencies at some cost to be linked to roadway data by traffic message channels. Regardless of the method of collection, agencies should consider implementing network wide speed data collection efforts to provide accurate data for speed management programs.

➔ **Appendix A.2 details how Bellevue, WA, used video cameras to analyze speeds across the transportation network.**

Limitations of Speed Information from Crash Data

The main safety data collected by agencies are police reported crash data. However, crash data also have their own limitations for application within a Safe System Approach for Speed Management framework. First is the problem of potential inaccuracy in the reporting methods. While crash data do indicate whether a driver was speeding, this variable may not be objective and may not accurately capture pre-crash driver behavior (Khattak, Ahmad, Wali, and Dumbaugh 2019). As mentioned, measures of impact speed in crash data are likely only estimates (Harmon, Hancock, Rodgman, Sandt, and Thomas, 2021). Secondly, completed crash reports frequently under report or miss collisions involving pedestrians, and the severity of pedestrian injuries are often inaccurate (Harmon, Hancock, Rodgman, Sandt, and Thomas 2021).

Agencies can use various statistical and data science methods to overcome these limitations, but not every agency will have the personnel capacity or technical knowledge to apply these corrections. One problem with assessing the utility of different speed management countermeasures is that transportation agencies do not always collect accurate project installation and completion data (Nordback et al. 2019). Accurate project data can allow practitioners to perform comparative before-after studies to get a better sense of the true capacity for a treatment to reduce speed-related crashes, but this methodology requires both a sufficient number of years of data before and after treatment installation and a statistical methodology (such as the Empirical Bayes approach) to account for potential biases in crash and traffic volume trends. Please see Carter et al. (2012) for more information on conducting accurate before-after studies.

Given these various limitations in available data, agencies seeking to supplement traditional systemic safety data may consider the following:

1. Collect network-wide operating speed data.
2. Maintain accurate records of project installation and completion.
3. Adopt Safe System Approach-based risk measures (e.g., FHWA's SSI method (Porter et al. 2021)) to identify risks proactively.

See the FHWA report *Safe System Approach in the Urban Core* for a case study on how to use the SSI methodology to identify risks at intersections (FHWA 2023).

3.2.4. Examples of Collecting and Analyzing Speed and Safety Data

In Section 3.1.5., the City of Portland case study was discussed to present an example of how an agency might work through the first stage of the Safe System Approach for Speed Management framework. The second stage, Collecting and Analyzing Speed and Safety Data, is crucial for the process outlined in that section. For agencies to determine roadways to identify as part of Vision Zero efforts, speed and safety data are critical. At a minimum, agencies may consider examining a network wide database of speed limit and crash data. Operating speed data should also be appended to the network dataset to the extent possible.

The Montgomery County, Maryland, speed program, discussed in Case Study A.4., began with a careful analysis of a variety of data types—resident complaints, crash data, active traveler volumes, and environmental data, among others—paired with operating speed data to identify locations where operating speeds exceeded posted speed limits. However, the County's analysis did not end at an examination of operating speeds; county personnel routinely visit sites with reported speed problems to inspect the locations and determine the feasibility of using enforcement cameras as well as their potential impacts on people walking nearby. These field visits can help determine the viability of enforcement efforts, but they may also indicate other countermeasures that may be more effective.

Agencies collecting speed and safety data as part of a Safe System Approach for Speed Management framework may consider the many types of data beyond simple crash counts and speed limits that can help them identify specific locations with speed problems, but also network wide risks related to speed. For example, under its Vision Zero program, Montgomery County's Planning Department combined a wide variety of data—including road user volumes, land use measures, equity indicators, roadway features, speed limits, transit locations, and more—to use in crash prediction models to identify locations of risk on segments and at intersections across its entire network (Montgomery County's Planning Department 2022).

Agencies with access to a wide variety of data may also develop systemic crash prediction models to locate network wide risks where speed may be a factor in crashes, but agencies may also simply consider the locations where operating speeds and speed limits differ from target speeds for the intended purpose of the roadway. To continue the example from Section 3.1.5, agencies seeking to improve pedestrian safety in the urban core may consider all locations where operating speeds, collected by law enforcement or as part of engineering speed studies exceed target speeds (i.e., 25 mph), and then combine these two data points to determine potential treatment locations. Crash data or hospitalization data (Harmon et al. 2021) may inform this location prioritization as well. At a minimum, agencies should consider collecting speed data on all roadways within a jurisdiction in order to make informed decisions aligned with the Safe System Approach.

3.3. Prioritizing Locations for Speed Management Proactively

A core principle of the Safe System Approach is that "safety is proactive. Proactive tools should be used to identify and mitigate latent risks in the transportation system, rather than waiting for crashes to occur and reacting afterwards (Doctor, Ngo, Ocel, Scurry, and Shaw 2020). Transportation agencies can use the Safe System Approach for Speed Management framework to proactively identify those locations where operating speeds exceed target speeds, which may increase the risk of death or serious injury to road users; take an area-based approach; and design roadways proactively to meet target speeds and prevent speed-related safety problems.

3.3.1. Prioritizing Locations for Systemic Countermeasure Implementation

Traditional safety analysis based on crash reports treats the problem after crashes have occurred. Further, the categories typically used to describe speeding-related crashes include "exceeded speed limit", "driving too fast for conditions", "following too closely", and "driving aggressively", which focus on human error as the crash contributing factor rather than fully describing the circumstances surrounding the crash. Practitioners can apply the Safe System Approach for Speed Management framework by adopting a systemic, proactive network screening and diagnosis of speeding-related crashes.

Systemic safety initiatives can use information from well documented serious crashes (fatal and serious injury crashes) to identify the most prevalent crash types, facility types, and risk factors (Preston, Storm, Bennett, and Wemple 2013; Thomas et al. 2018). This information enables an agency to identify locations with roadway characteristics similar to those of known fatal and serious crash locations and preemptively prevent crashes from occurring at those sites (FHWA 2019). Depending on the type of countermeasure used, it may be more effective and proactive to implement several low cost projects that address risk across the entire roadway network rather than selecting expensive countermeasures that only address speed-related safety problems at a small number of hot spots. See Gross, Harmon, Bahar, and Peach (2016) for more information on the balance of countermeasure cost and crashes prevented.

➔ **Appendix A.9 contains an interesting case study on a network-wide speed management program in Australia.**

The Safe System Approach for Speed Management framework, with its emphasis on injury minimization, fits into the first four components of a systemic safety project selection procedure. For example, an agency might do the following:

1. Select high speed angle crashes (likely to result in fatalities) as the focus crash type.
2. Use crash data to identify intersections where a combination of posted speed limits and signal timing plans correspond to the potential for high speed angle crashes with increased risk of severity. The use of crash data in this approach is proactive and intended to be used in predictive modeling to identify locations of risk rather than to treat hot spots.
3. Select speed management treatments (e.g., conversion to roundabout) that will reduce the potential for high-speed angle crashes to occur.
4. Prioritize treatment intersections based on the greatest potential for fatalities to occur.

The final two steps of the systemic safety process are also relevant but relate less to the Safe System Approach. Agencies should regularly collect data and monitor safety so that speed management programs can be fine-tuned; these data will also enable agencies to communicate the benefits of speed management to the public to aid in building compliance with network-wide speed management applications.

Prioritization may vary depending on the type of jurisdiction responsible for project delivery. State agencies implementing speed management treatments along State-owned roads may consider using a speed management emphasis area, as identified in a SHSP, to prioritize State highway safety improvement projects and ensure that the riskiest sites are prioritized.

Oregon DOT (ODOT) has implemented this type of risk-based application of (primarily) HSIP funds through its All Roads Transportation Safety (ARTS) program. As part of this program, ODOT splits roadway safety funds evenly between hot spot treatments and systemic treatments and then prioritizes active prevention through systemic projects. Researchers collaborating with ODOT to implement a systemic approach to pedestrian and bicycle crash prevention collected various data sets and then worked with ODOT to assign weights to risk factors identified in these datasets. One of the most important risk factors identified was whether the posted speed limit exceeds 35 mph.

After weights were assigned, ODOT then used these weights to score State roadways for treatment (Foster et al. 2020). Practitioners are encouraged to review Foster et al. (2020) to see how ODOT implemented a systemic approach using speed limit data to identify locations for treatment using HSIP funds allocated through its ARTS program.

3.3.2. Schemes for Prioritization

There are a variety of data sources or metrics that could be used to prioritize treating locations in addition to the data discussed in Section 3.2.2. These considerations include equity and desired activity. These prioritization schemes can be used in conjunction with the systemic approach discussed in Section 3.3.1. For example, agencies may find success in implementing speed management countermeasures by systemically identifying locations that pose risks to specific types of road users (e.g., VRUs) and then may rank those treatment locations by considering equity implications or desired activity levels. This approach could lead an agency to prioritize the top ten sites where the speed limits are highest and where pedestrians should be the most highly prioritized type of road user.

Regardless of the method used for project prioritization, agencies may involve relevant stakeholders, particularly from locations where projects will be implemented, to ensure that speed management activities are beneficial to those most affected and to continue to build a shared vision for speed management.

Equity

Historically, inequitable transportation planning and development patterns have led to the social cost of traffic crashes being born unequally by Black and Indigenous road users or populations in marginalized communities (Johns Hopkins University, ITE, and the FIA Foundation 2021; USDOT 2022a). Throughout the United States, roadways have been designed and built to provide high speeds through some communities at the expense of the people living in those communities. In the Portland, Oregon, metropolitan area, 67 percent of pedestrian fatalities and 72 percent of serious injury pedestrian crashes occur in equity focus areas where people of color (especially Black and Indigenous peoples), people with lower income, and people with limited English proficiency are disproportionately affected by crashes. Additionally, 50 percent of high-injury corridors (250 miles) in the Portland metro area are in areas with above average densities of people of color, while only 41 percent of the population lives in these areas (FHWA 2020c).

Other research efforts report similar inequitable safety outcomes around the country, confirming that pedestrian fatalities tend to be concentrated in low-income communities and communities of color, while Native American communities especially are disproportionately at risk of all total traffic fatalities (Grant and Bowen 2020). These locations may provide significant net benefits to traffic safety if speed-related problems can be addressed.

Desired Activity

Placemaking may be a useful concept for framing local transportation and planning design decisions with an emphasis on speed management. Placemaking is an approach to planning public spaces—especially transportation facilities—wherein the physical and social qualities of a public space are balanced to promote health and well-being (Flynn and Yassin 2012). In the context of transportation, the placemaking approach entails carefully considering who can (or should) use a roadway to reach a destination. Agencies can integrate placemaking concepts with speed management by considering the land use context of a location in terms of movement and place.

A practical application of using placemaking concepts to prioritize locations for speed management projects in the United States is a city identifying locations intended to serve as places that currently have a significant number of deaths or serious injuries. At these locations, it may be beneficial to both lower speed limits and implement traffic calming measures, or to provide separation for pedestrians and bicyclists if vehicular movement is still necessary near the place. The PBOT, as part of its Vision Zero initiative, created a Simplified Decision Matrix (**Figure 13** in the Appendix) to assist staff in creating low speed environments wherever pedestrians and bicyclists will use the roadway (Vision Zero Network n.d.). These provisions include low speed limits, dedicated sidewalks, bike lanes (even with low speed limits), and minimum lane widths when pedestrians and bicyclists may be present. The combined effect is to provide visual friction on roadways where pedestrian and bicyclist activity is expected and to provide separation to pedestrians and bicyclists when higher mobility is desired.

➔ For more information on speed management activities and PBOT's vision of the Safe System Approach, see Appendix A.6.

Other jurisdictions in the United States have developed similar modal hierarchies for roadway projects and prioritized funding to improve the safety of road users based on desired activity. For example, in its Complete Streets Policy, the City of Baltimore developed the modal hierarchy that prioritizes, in the following order (City of Baltimore 2021):

1. Walking
2. Cycling, public transit, and micromobility
3. Taxis, commercial transit, and shared vehicles
4. Single occupant motor vehicles

Given the biomechanical vulnerability of pedestrians and bicyclists discussed previously, proactively prioritizing streets that improve safety for these modes rather than addressing where crashes occur is an effective method to address safety issues and apply Safe System principles.

Agencies seeking to incorporate movement and place metrics into a prioritization framework may also consider multimodal indicators of road use comfort, also known as "walkability" and "bikeability." The walkable or bikeable nature of a roadway is often measured in terms of the level of service or the amount of traffic stress non-motorized road users feel on roadway. The walkability and bikeability of a roadway are directly related to the design of the roadway environment, so while they may not be direct measures of safety, they can act as surrogate indicators of risk (Caviedes and Figliozzi 2018).

Researchers have integrated the concept of place into crash prediction models and found that spatial indicators of pedestrian and bicyclist activity are important for determining where crashes might occur (Wang, Huang, and Zeng 2017). If agencies have access to spatial correlates of activity, like pedestrian level of service, these data may help agencies identify locations where operating speeds cause stress to nonmotorized road users. This information can then be used to manage speeds proactively at these locations before crashes occur. A recent National Cooperative Highway Research Program (NCHRP) publication provides information to practitioners seeking to measure pedestrian level of service for consideration using *Highway Capacity Manual* methodologies (Ryus et al. 2022).

3.3.3. Examples of Proactively Prioritizing Locations for Speed Management

The third stage of the Safe System Approach for Speed Management framework directly builds upon the data collection activities described in Section 3.2.4. The City of Fremont's speed management activities, discussed in Case Study A.3., illustrate one example of an agency extending its Vision Zero activities from vision framing to data collection to project prioritization.

As discussed in Section 3.2.4., a variety of different data types can reveal locations along a roadway network that may have speed problems. As part of its traffic safety management program, the City of Fremont used multiple methods of project prioritization, including the following:

- Hot spot identification of locations with clear safety problems
- Systemic identifications of locations that can be proactively treated with systemic countermeasures
- Safe neighborhoods program to reduce speeds in residential areas

These various prioritization schemes can leverage different data to give agencies a list of potential locations for treatment. Hot spot identification may rely on crash data, but systemic and neighborhood approaches may simply rely on datasets of operating speeds and speed limits. The City of Fremont reports that its approach to speed management and project selection has demonstrated both a 45 percent decrease in fatal and serious injury crashes and a 44 percent decrease in crashes involving speeding.

To continue the example from Section 3.2.4., an agency that has collected data on roadways in the urban core where the target speed is 25 mph to facilitate pedestrian travel may examine all roadways of that type in the entire urban core network and then prioritize locations for treatment based on the following factors:

1. Where operating speeds and speed limits are in excess of target speeds (and by how much)
2. Where systemic, low-cost countermeasures can be installed quickly

This approach to prioritization may not even require the use of crash data for agencies to quickly make countermeasure selection decisions, enabling agencies to respond to speed problems proactively rather than reactively.

3.4. Selecting Speed Management Strategies

Transportation practitioners can implement several strategies to manage speeds on roadways. The initial consideration in speed management should be setting speed limits that are both consistent with the roadway context and safe for all road users (FHWA 2017c). Higher speed limits are linked to higher crash severity (Doecke, Kloeden, Dutschke, and Baldock 2018), and studies show that lowering speed limits can lower vehicle speeds (Hu and Cicchino 2020). A few strategies for an effective speed management program are described in this section.

3.4.1. Determine Appropriate Speed Limits to Match Target Speeds

The Safe System Approach can be applied to speed limit setting by incorporating the needs of all road users rather than focusing on vehicle operational speeds. Setting appropriate speed limits to reduce the risk drivers impose on others, especially VRUs, and on themselves is an FHWA Proven Safety Countermeasure (FHWA 2021). Target speeds should be consistent with a specific context to provide both mobility for motor vehicles and a safe environment for pedestrians, bicyclists, and public transit users. Setting appropriate speed limits can reduce fatalities and serious injuries (Doecke, Kloeden, Dutschke, and Baldock 2018; FDOT 2016).

Where statutory speed limits do not fit a specific road, traffic context, or land use, speed zones may be established, and speed limits may be set by an engineering study, taking into account the context of the location. As an example, FDOT reduced the speed limit on the Busch Boulevard corridor from 45 mph to 35 mph (FDOT 2018). Further, jurisdictions can develop their own methodology to set speed limits based on target speeds. The PBOT developed a decision matrix for speed zones on non-arterial roads with posted speed limits greater than 25 mph, with focus on the safety of VRUs (PBOT 2016).

Although matching operating speeds with target speeds is the end goal, intermediate target speeds may be necessary to achieve public buy-in. The Washington State Department of Transportation (WSDOT) establishes target speeds and considers a phased approach where the operating speed exceeds the target speed by 5 mph or more (Washington Injury Minimization and Speed Management Policy and Guidelines Workgroup 2020). WSDOT uses an engineering study to determine iterative speed limits and implements speed management techniques. Incremental adjustments of 5 mph or more are made until the target speed is achieved.

3.4.2. Inform the Public about Speed Management Benefits to Build Support

Lower speeds in urban environments promote physical activities such as walking and cycling. Lower speed limits also improve accessibility and equity of access to the transportation system. Creating environments where all people feel safe further helps to make a public network accessible to all members of the public.

Lower speeds also reduce vehicle emissions, and even minor decreases in operating speed result in substantial reductions in carbon emitted from vehicles. These reductions decrease the impact of emissions on climate change and improve air quality, especially for road users not inside vehicles (Gonzalez and Lungu 2021). Improved air quality resulting from lower speeds can result in fewer negative health impacts due to air pollution. Again, this is more important for the vulnerable members of society who have existing health conditions.

3.4.3. Identify and Implement Roadway Redesign or Behavioral Treatments to Support Speed Limit Changes

Engineering and enforcement measures can be implemented to support lower speed limits. In addition to lowering the default arterial and non-arterial speed limits to 25 mph and 20 mph (from 30 mph and 25 mph), the City of Seattle used road diets, signal timing modifications, and increased speed limit sign density to reduce vehicular speeds (City of Seattle, 2015). Similarly, New York City created a speeding solutions toolkit that incorporated school zone automated enforcement, police enforcement, speed humps, speed cushions, and street redesign projects to support the reduced citywide default speed limit of 25 mph (City of New York 2020).

➔ See how New York City took a comprehensive approach to speed management using the Speeding Solutions Toolkit, as discussed in Appendix A.5.

In summary, examples of countermeasures that practitioners should consider using to support context-sensitive speed limits include the following:

Roadway Treatments

Roadway treatments include vertical deflections (e.g., speed humps, speed tables, raised intersections), horizontal shifts (e.g., chicanes), roadway narrowing (e.g., road diet, lane-width reduction), intersection treatments (e.g., closures, raised intersections, protected intersections, intersection turn calming), and signal timing modifications. Typically, residential streets or streets where the primary function is to provide access to abutting residential property are appropriate for vertical deflections. Consideration should be given to minimizing conflicts with emergency vehicles and transit services (FHWA and ITE 2017). Further, vertical deflections must be properly designed to avoid adverse impacts on individuals with disabilities. Speed humps, which include a raised area in the roadway pavement surface extending across the travel way with significant length, are recommended to promote vehicular speed reduction without compromising comfort for all other road users (ITE 2022).

Table 8 lists complementary infrastructure treatments that were identified as being effective in reducing speeds and crashes (Hillier, Makwasha, and Turner 2016). These vary between roadway treatments and behavioral treatments and may have different uses in different contexts. Please refer to Hillier, Makwasha, and Turner (2016) for more information.

Table 8. Complementary speed management infrastructure treatments: speed and crash reductions.

Treatment	Speed Reduction	Crash Reduction
Vehicle Activated Signs (e.g., Changeable Message Signs)	3 mph reduction in 85th percentile speed	70% reduction in crashes
Roundabouts	6 mph reduction in 85th percentile speed	75% reduction in crashes
Raised Intersections (intersections with vertical deflection)	5 mph reduction in 85th percentile speed Not common in U.S.	40% reduction in casualty crashes
Horizontal Deflection (e.g., curb extensions)	Up to 3 mph reduction in speed	30% reduction in pedestrian crashes
Perceptual Countermeasures (e.g., painted speed bars that make drivers feel they need to slow down)	8 mph reduction in 85th percentile speed from perceptual narrowing 7 mph reduction in 85th percentile speed from lane narrowing through buildings, parked cars, etc. Up to 5 mph reduction in 85th percentile speed from markings that give the appearance of travelling faster on the approach to an intersection	-
Transverse Rumble Strips	Up to 3 mph reduction in speed	30% reduction in fatal and serious injury crashes
Reduce Excessive Sight Distance at Roundabouts	Up to 12 mph reduction in 85th percentile speed at roundabouts	Up to 40% (CMF 0.60) for reductions in excess sight distances at roundabouts
Lower speed limits	4 mph reduction in 85th percentile speed. Note: In other literature, this varies greatly depending on the speed environment. For example, assuming a 4 mph speed reduction in an urban environment with high vulnerable road user demand would be unreasonable.	25% reduction in casualty crashes
Variable Speed Limits (VSL)	Evidence of overall reductions in speed	8% reduction in casualty crashes
Changeable Message Signs	1 mph reduction in mean speed	10% reduction in injury crashes

- No data.

Source: Hillier, P., Makwasha, T., and Turner, B. (2016). Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice. Sydney: Austroads.

➔ **Refer to Appendix A.10 to see how speed limit changes fit into a broader speed management program in South Korea.**

Behavioral Treatments

Behavioral treatments include increased speed limit sign density, speed feedback signs, traditional enforcement, and automated enforcement. Speed safety cameras are included in FHWA's Proven Safety Countermeasures (FHWA Office of Safety 2021). It is important to note that a few of these countermeasures may not be useful in certain temporal distributions. For example, police enforcement may not always be available due to other occupational demands, and existing design issues that can lead to higher speeds (i.e., capacity) may not be addressed by these behavioral countermeasures.

3.4.4. Countermeasures for Improving Speed Limit Compliance

A posted speed limit is sometimes the same as the statutory speed set by the State legislature, or it is established by a city, county, or State transportation agency (FHWA 2017a). Modifying speed limits based on a specific context may not always be possible. In certain cases, the existing posted speed limit is appropriate based on the context but concerns with speed limit compliance exist. Practitioners can still implement supporting treatments for reducing vehicular travel speeds without changing the speed limits, such as through public outreach, behavioral treatments, and roadway treatments.

Inform the Public and Get Buy-In

In Montgomery County, Maryland, more than 60 percent of residents supported their automated enforcement program after it started following extensive community outreach. After final approval for a camera location, the site must be advertised in a newspaper of general circulation prior to conducting enforcement (Montgomery County Department of Police 2022).

Identify and Implement Behavioral Treatments To Support Speed Limits

Behavioral treatments such as increased speed limit sign density, speed feedback signs, traditional enforcement, and automated speed safety camera enforcement can support speed limit compliance.

Identify and Implement Roadway Design Changes To Achieve Speed Limits

In addition to driver behavior, the Safe System Approach addresses human vulnerability to crash impact forces, and the roadway infrastructure can be designed to reduce crash severity. Vertical deflections (e.g., speed humps, speed tables, or raised crosswalks), horizontal shifts (e.g., chicanes), roadway narrowing (e.g., road diet, lane width reduction), roadway closures (e.g., median barriers, hardened centerlines), intersection treatments (e.g., raised intersections, protected intersections, intersection turn calming), and signal timing modifications are effective measures to reduce travel speeds.

3.4.5. Speed Management Resources

As discussed, speed management includes setting the appropriate speed limit, when possible, and supporting lower travel speeds with behavioral and roadway design countermeasures.

There are several speed management resources available for practitioners that may help readers select appropriate countermeasures from **Table 8**, as well as other interventions that may not be referenced there. Each tool has specific context, advantages, and disadvantages, as discussed below. It is important to note that these resources can be used as part of an engineering study for non-statutory speed limits; however, they do not replace any required engineering study.

Speed Limit Resources

USLIMITS2 (FHWA 2020b): USLIMITS2 is a web-based tool that helps practitioners set reasonable, safe, and consistent speed limits for specific segments of roads. The tool is applicable to all types of roads except for school zones or construction zones. The tool considers the following major factors: operating speed (50th and 85th percentile), annual average daily traffic, roadway characteristics and geometric conditions, level of development in the area around the road, crash and injury rates, presence of on-street parking, extent of pedestrian and bicyclist activity, as well as several other factors depending on the road type. USLIMITS2 is an expert systems tool and has increased safety considerations compared to previous versions. For example, USLIMITS2 recommends speed limits close to the 50th percentile speed instead of the 85th percentile speed for roadway segments that experience high pedestrian and bicyclist activities. USLIMITS2 is currently being updated under project NCHRP 03-139 "Next Generation of the USLIMITS2 Speed Limit Setting Expert System."

NACTO City Limits (NACTO 2020): This tool provides cities with technical and policy guidance on setting safe speed limits on urban streets, which pose the most complex and challenging scenarios for determining speed limits where there is considerable pedestrian and bicyclist presence. NACTO City Limits is a context-sensitive method that includes three primary tools for setting speed limits in urban areas: setting default speed limits on many streets at once, designating slow-speed zones in sensitive areas, and setting corridor speed limits on high-priority major streets. This tool focuses on a defined safety target to set speed limits rather than percentile-based systems that focus on operating speeds, allowing cities to holistically evaluate who is using streets and how those individuals are using them.

NCHRP Report 966 (Fitzpatrick, Das, Pratt, Dixon, and Gates 2021): This manual provides a procedure for setting speed limits, a practitioner user manual explaining the speed limit setting procedure, and a speed limit setting tool. The tool considers factors beyond the 85th percentile speed, including both driver speed choice and safety associated with the roadway. NCHRP Report 966 includes the following variables for speed limit setting: roadway context, roadway type, speed data (50th percentile speed, 85th percentile speed, and maximum speed limit), site characteristics (segment length, traffic volumes, number of lanes, pedestrian and bicyclist activity level, pedestrian facilities, and other attributes describing the segment's design and traffic control characteristics), and crash data (crash frequency, years of crash data, crash severity, exposure, and others). This tool can be used on all road types (interstates, principal arterials, minor arterials, collectors, locals) and across all contexts (rural, rural town, suburban, urban, urban core).

Infrastructure/Speed Limit Relationship in Relation to Road Safety Outcomes (Jurewicz and Turner 2010): This report was published by Austroads and focuses on the Safe System Approach. It provides advice to jurisdictions on appropriate speed limit setting policy in light of injury minimization. This advice was based on the improved understanding of the relationships between infrastructure, speed limits, driver selection of speeds, and crash outcomes.

Infrastructure Resources

FHWA Road Diet Guide (Knapp et al. 2014): This tool guides practitioners through the decision-making process to determine if road diets are a good fit for a certain corridor. It also provides design assistance and encourages post-implementation evaluation. The road diet feasibility determination in this guide includes safety factors (crash patterns); context-sensitive solutions and Complete Streets qualities; operational factors (speed, traffic volumes, level of service, quality of service, and so on); bicycle, pedestrian, and freight considerations; right-of-way availability and cost; parking; the presence of railroad crossings; public outreach; public relations; and political considerations.

FHWA Self-Enforcing Roadways Guidance Report (Donnell, Kersavage, and Fontana Tierney 2018): This tool guides users to identify methods that may produce self-enforcing, or self-explaining, roadways during the geometric design process. The FHWA Self-Enforcing Roadways Guidance Report describes six methods for self-enforcing roads: speed feedback loop, inferred design speed approach, design consistency methods, application of existing geometric design criteria, combination of signs and pavement markings, and setting rational speed limits. This tool focuses on methods to mitigate speeding-related crashes on planned and existing two-lane rural highways with posted speed limits of 35 mph or greater.

Behavioral Resources

FHWA Speed Safety Cameras (FHWA Office of Safety, 2021): Speed safety cameras are an FHWA proven safety countermeasure. Agencies can use speed safety cameras as an effective and reliable technology to supplement more traditional methods of enforcement, engineering measures, and education to alter the social norms of speeding. Speed safety cameras use speed measurement devices that detect speeding and capture photographic or video evidence of vehicles that are violating a set speed threshold.

Speed feedback signs: Although there is no specific tool for practitioners to follow regarding the use of speed feedback signs, research can guide practitioners on how this countermeasure is effective in reducing speeds. An example includes use of dynamic speed feedback signs in small rural communities in Iowa (Hallmark, Hawkins, and Knickerbocker 2015).

Federal Funding Resources

Highway Safety Improvement Program: Where consistent with HSIP requirements, Federal funding can be used through the HSIP to implement speed management countermeasures specified in State SHSPs. The role of the HSIP and SHSP in a Safe System Approach for speed management are discussed in greater depth in Section 3.1.3.

Safe Streets and Roads for All (SS4A): The Bipartisan Infrastructure Law (Pub. L. No. 117-58) establishes a new SS4A competitive grant program, which sets aside $5 billion over 5 years. Under this grant, eligible jurisdictions can apply to receive funds to implement speed management efforts, among other safety-oriented projects and activities. In addition, MPOs, political subdivisions of a State, federally recognized Tribal governments, and multijurisdictional groups of these entities are all eligible to apply for these grants to develop Comprehensive Safety Action Plans; conduct planning, design, and development activities for projects and strategies identified in a Comprehensive Safety Action Plan; and carry out projects and strategies identified in a Comprehensive Safety Action Plan (USDOT 2022b).

3.4.6. Examples of Selecting Speed Management Countermeasures

Section 3.3.3. discussed prioritization methods for proactively using data to identify locations suitable for speed management countermeasures. Two case studies in the Appendix provide examples of how agencies have moved from prioritization to implementation, with a different emphasis in each case.

The City of Bellevue—as discussed in Case Study A.2.—conducted a comprehensive speed data collection process and determined its own Neighborhood Slow Zone program was a viable method for prioritizing countermeasures that could be installed quickly. The city began systemically installing speed feedback signs across this network of neighborhood slow zones to reduce vehicle speeds. Fisher et al. (2021) reports that the general research consensus is that dynamic speed feedback signs are effective across a comprehensive range of location types at reducing operating speeds, with many studies showing reductions in mean speeds, 85th percentile speeds, and speeding behaviors.

Conversely, the example of the City of Seattle—discussed in Case Study A.7.—demonstrates that simply lowering speed limits systemically as part of a proactive speed management program can produce significant benefits to safety. The city's efforts, which included lower speed limits and increased speed limit sign density, produced the following benefits:

- A 22 percent reduction in all crashes and 18 percent reduction in injury crashes
- A 10 percent reduction in 50th percentile speeds and 7 percent reduction in 85th percentile speeds
- A 54 percent reduction in the number of vehicles traveling at or faster than 40 mph

Critically, the city did more than just lower speed limits at locations where the roadway design may not be self-explanatory to cue motorists to drive at the target speeds. For example, in addition to lowering the speed limit on Rainier Avenue South, the city also implemented a road diet and converted the road from four lanes to three lanes. Speed limit reductions alone may not always be sufficient to change operating speeds, so agencies may also consider geometric design changes that will increase visual friction to slow drivers down.

To continue the example from Section 3.3.3., after an agency has identified urban core roadways where speed limits and operating speeds exceed the intended target speed of 25 mph, they may then identify locations where systemic, low-cost treatments (e.g., speed feedback signs or speed tables) can slow traffic to 25 mph. They may also identify locations where the number of lanes or building setbacks along corridors induce speeds above 25 mph and then select those sites for more extensive reconstruction projects. Agencies may consider scanning the list of different countermeasures discussed in Section 3.3.3 and then diagnose the roadway environments along the prioritized list of networks to determine which countermeasures will work best to slow driver speeds.

3.5. Ongoing Monitoring, Evaluation, and Adjustment

Agencies implementing a Safe System Approach for Speed Management framework are encouraged to think of the framework not as a linear process but as a cycle moving the agency towards prevention of death and serious injury on their roadways. After agencies have identified locations for treatment, prioritized projects based on equity and alignment with a speed management vision, and implemented countermeasures to produce target speeds at those locations, agencies are still encouraged to collect speed and risk data and to monitor the outcomes of their projects.

Safety performance can change over time, and speeding behavior can migrate across a network, so agencies are encouraged to continually evaluate their progress toward network wide target speeds to ensure that long-term safety goals, such as those specified in the SHSP, are met. Speed management activities undertaken as part of the Safe System Approach may also be iterative and incremental in nature. Some agencies choose to redesign select components of a roadway when Safe System principles cannot be achieved in the current stage of implementation. Some agencies set incremental target speeds when operating speeds are substantially higher than the desired target speeds (FDOT 2022). Others may install traffic signals that separate some road users in time even if full separation in space would be more effective (ITE 2020). This approach can still provide a benefit because each incremental improvement is a progressive investment towards the final Safe System (Corben 2020).

This stepwise approach may be more effective than high-cost infrastructure changes that do not progress towards Safe System outcomes because those reconfigurations may not properly address roadway risks related to speed. These types of improvements will require significant investment later to address the true sources of risks and will likely require a complete redesign. For example, if there is an intersection that requires a roundabout to be Safe Systems aligned and traffic signals are installed instead, to still align it to a Safe System Approach, the traffic lights might need to be removed later and a roundabout installed.

The remainder of this section briefly discusses the following:

- Monitoring and data collection
- Evaluation of speed management programs
- Speed enforcement
- Education of road users
- Useful technologies

3.5.1. Monitoring and Data Collection

It is critical that agencies collect data after the implementation of speed management countermeasures to ensure that the effectiveness of those countermeasures can be evaluated. Data collection is also important for discerning the applicability of different treatments and for getting public support for those countermeasures. A city may learn that a specific speed management countermeasure, such as roundabouts, may help produce target speeds and reduce total crash severity but may have unexpected safety consequences, such as increased crash severity for pedestrians and in certain contexts (Khan and Habib 2022). Agencies should continue to monitor crash and speed data after implementation of countermeasures to discern what these unexpected effects may be so that additional treatments can be identified, if needed.

Ongoing data collection can also be important for maintaining a vision for speed management within a jurisdiction. After the City of Seattle updated its speed limit policy as part of its Vision Zero program, the city collected data on several corridors to ensure that the changes in speed limit signs were producing the desired target speeds. Seattle found that not only had 85th percentile speeds on the study corridors decreased, but injury crashes had also decreased by at least 10 percent on each corridor (City of Seattle 2020). Seattle was able to produce these findings and demonstrate to the public that its Vision Zero program and connected speed management activities are making the roads safer for all road users. This data collection also allows Seattle to provide feedback to road users regarding target speeds and allows them to promote these target speeds so that road users expect consistently low speeds as new projects are developed. Ongoing data collection has been pivotal for the City of Seattle's success.

3.5.2. Evaluate Current Speed Management Efforts

Monitoring and evaluating speed management programs helps road authorities determine the effectiveness of these programs. Monitoring and evaluation can also be used to perform the following activities:

- Demonstrate the extent to which road authorities are achieving their Safe System goals
- Improve decision making for future programs
- Determine locations where additional interventions may be required to improve compliance with safe and appropriate speeds (i.e., improve levels of speed limit compliance)
- Demonstrate the safety benefits of speed management programs to the public

In addition to the data types discussed for analysis and evaluation in Section 3.2.2, practitioners often collect behavioral data after projects are completed to ensure that the desired speed and safety goals have been achieved. These additional data types may include the following:

- Awareness of speed management
- Perceptions of speed management activities
- Road user counts and latent demand (e.g., trips through new, slower roadway segments)
- Road user behavior (e.g., yielding)

Agencies can collect these data using public surveys mailed to residents who live near project locations (or commuters who use those segments), through intercept surveys on those segments, through counts taken before and after project implementation, and through evaluations of recorded video data. These types of data can lend context to other objective measures of efficacy (e.g., crash and speed data) and can help agencies understand how the public perceives these projects in case modifications need to be made or the benefits need to be more successfully communicated.

3.5.3. Speed Enforcement

Enforcement is often vital for establishing initial driver compliance with target speeds. However, as discussed in Section 2.3, operating speed and driver behavior are intrinsically linked to roadway design. Drivers select their speeds based on the prevailing conditions of the roadway environment, and research has demonstrated that speed enforcement may be less effective at producing long-term changes in speed behavior when compared to other speed management techniques (Sanders, Judelman, and Schooley 2019). Speed behavior can vary in proximity to even speed safety cameras, so ongoing data collection is necessary to determine if and how to apply enforcement as a component of a speed management effort (Decina, Thomas, Srinivasan, and Staplin 2007).

Speed safety cameras can be highly effective, as illustrated in the Montgomery County, Maryland, case study in the Appendix. Montgomery County initiated an automated speed enforcement program in 2007 and has integrated this program within its Vision Zero plan. In this example, automated speed enforcement is used to support roadway design to create a culture of compliance with target speeds. The Montgomery County application is notable because the cameras are installed on a corridor basis and serve as a systemic treatment that enhances the County's speed management program. Evaluations of this program have linked it to a 62 percent reduction in the likelihood that a vehicle will travel at more than 10 mph above the speed limit and a 19 percent reduction in the likelihood that a crash will result in a serious or fatal injury. The County intends to integrate its automated speed enforcement program with other speed management efforts as part of its Vision Zero work plan (Montgomery County Department of Police 2022).

➔ **For more information on Montgomery County's automated speed enforcement program and how the County integrated speed safety cameras with their Vision Zero program, see Appendix A.4.**

Other agencies have also reported benefits from the installation of speed safety cameras. New York City reports that its camera program, installed in 750 school speed zones, corresponded to a 72 percent drop in speeding behavior in school zones from 2014 to 2020 (City of New York 2020). The City and County of San Francisco (2015) examined speed safety camera practices across the United States and reported that speed safety camera programs have the benefit of addressing speeding violations more efficiently than traditional police enforcement programs. The City and County of San Francisco's report also concluded that speed safety camera programs are effective at reducing speeds and crashes when used as part of larger speed management programs (2015). Finally, international literature supports the reported safety benefits of camera programs. Li et al. (2020) examined 464 speed cameras at sites across England and analyzed the efficacy of multiple camera installations for reducing crashes. The researchers concluded that speed cameras are most effective at a radius of 200 m (approximately 656 ft). However, when multiple cameras are installed within that radius, injury crashes may be reduced by 21.4 percent, a significant difference when compared to a reduction of 13.2 percent when only a single camera is installed.

Agencies considering implementing speed enforcement as part of their speed management programs should consider two key parameters: safety and equity. First, the purpose of a speed safety camera program should be to improve roadway safety. Road users must believe that cameras are located for their benefit and without profit incentive. Second, any speed enforcement program should be carefully considered in terms of equity and potential benefit. Even automated speed enforcement, with its potential for unbiased deployment, may still inadvertently harm some communities if not sited in conjunction with roadway design considerations (Sutton and Tilahun 2022). Equity must always be considered in the application of any type of enforcement, as Black and Indigenous communities often bear the brunt of enforcement activities. Whenever possible, agencies should consider alternatives to speed enforcement to produce target speeds.

3.5.4. Education of Road Users

Much of this report has focused on stakeholders creating a shared vision for speed management, but this vision should also include road users. As part of ongoing efforts to achieve target speeds, agencies should strive to create social norms around safe speeds and safe road use to maintain public support. The Safe System Approach emphasizes that the responsibility to prevent fatalities and serious injuries on roadways is shared by all stakeholders, so agencies implementing a Safe System Approach for Speed Management should be transparent and positive when crafting a vision for speed management.

One method for educating road users and traffic safety stakeholders about target speeds is to explicitly engage in communication activities related to traffic safety culture. It is critical that agencies communicate the benefits of speed management (see the City of Seattle Case Study in the Appendix) to ensure that drivers internalize the benefits of reduced speeds, including walkable and bikeable communities, health benefits, reduced stress, and reduced crashes for all. To increase public awareness of the potential of safe roads, the Safe Systems Consortium recommends practitioners develop and conduct Vision Zero/Safe System awareness campaigns that are culturally sensitive and based on evidence (Johns Hopkins University, ITE, and the FIA Foundation 2021).

A proactive safety culture in transportation can be achieved when road users actively go beyond what is legally required of them (Finley, Otto, Ward, and Arpin 2019). This can include surpassing legal obligations when making decisions that impact their own safety; for example, not traveling over 19 mph in high density pedestrian areas, even though this might be legally allowed. However, it can also mean influencing others in a manner that encourages them against engaging in unsafe activities. An example of this could be where friends prevent each other fromspeeding or remind each other to buckle up.

Studies have shown that people in the United States engage in some measure of basic safety behavior on the road. However, a minority of people don't engage in such behavior and therefore contribute a higher crash risk to the system. Proactive safety culture applies the Safe System Approach to creating redundancy by leveraging safer driving behaviors by the majority of users to compensate for noncompliant and unsafe behaviors from a minority of drivers. Agencies can seek to implement social norms around safe road use, such as engagement with communities, marketing, teaching at schools, encouraging workplace policies around safe driving, and encouraging discussions between law enforcement and the public (Finley, Otto, Ward, and Arpin 2019).

3.5.5. Useful Technologies

Agencies are encouraged to monitor ongoing research around the Safe System Approach and potentially beneficial technologies—such as connected infrastructure or automated systems—for application within a speed management program. Transportation technology is developing rapidly, and FHWA frequently updates its Proven Safety Countermeasures with the latest innovations. Agencies are encouraged to review this page to identify new methods for speed management, and, if implemented, to collect data on those methods so that the public can be educated on their uses and best practices can be shared.

3.5.6. Examples of Monitoring, Evaluation, and Adjustment

The fifth stage of the Safe System Approach for Speed Management framework is for agencies to conduct monitoring, evaluation, and adjustment activities to determine whether existing speed management activities are working appropriately, or further countermeasures are needed. As mentioned, speed behaviors can migrate across a network as drivers adapt to corridor-specific changes, and some countermeasures may be less effective than expected. Additionally, speed limit changes may not always cause decreases in speed if roadway environments themselves are not modified or if the social norms surrounding speeding behaviors continue, so agencies may need to assess the efficacy of their speed management programs and be open to making necessary adjustments.

Several case studies in the Appendix of this report discuss evaluation and monitoring efforts agencies may undertake to determine the efficacy of their programs. One example of an important evaluation is New York City DOT's before-after analysis of its speed safety camera program to determine if the countermeasure had an impact on speeding near school zones. New York City compared speeds from 2014 to 2020 and determined that the camera program had produced a 72 percent decrease in speeding behavior near school zone camera locations. New York City also evaluated the effects of its speed hump and speed cushion installations to determine if these countermeasures had actually reduced speeds following implementation and reported a 17 percent reduction in injuries at nine speed cushion sites in 2021 compared to 2017. More information on how New York City DOT conducted its before-after evaluations can be found in Case Study A.5.

To conclude the example from Section 3.4.6, an agency may continue monitoring operating speeds on all urban core roadways treated with speed limit reductions, speed feedback signs, and road diets. This ongoing monitoring should include operating speeds and should be conducted over several years to avoid a regression to the mean in both crashes and driver speeds. If the example agency cited in Section 3.4.6 were to discover, for example, that drivers on the roadways where speed feedback signs had been installed were once again driving above the target speed of 25 mph six months after the installation of those signs, the agency may need to determine whether additional changes to roadway design, such as bulb-outs or speed safety cameras, would be appropriate to reduce operating speed back to target speeds. Without this type of post-installation data collection, the agency may be unable to properly diagnose changes in speed problems or determine if its speed management activities remain effective. Therefore, any agencies undertaking a Safe System Approach to Speed Management should consider collecting speed and safety data through all parts of the program's lifespan and use these data to make appropriate programmatic changes.

4. CONCLUSION

Speeding, exceeding the posted speed limits, or traveling too fast for conditions was a contributing factor in almost 29 percent of all fatalities in 2021. Of the 42,939 fatalities that occurred on our Nation's roadways that year, 12,330 were speeding-related—an increase of 7.9 percent from 2020 (Stewart 2023). Speed directly influences the severity of traffic crashes because the laws of physics dictate that energy released in a crash is directly proportional to the velocity of the vehicle(s) involved. Therefore, speed management is one of the most important components of a Safe System Approach to traffic safety, and any effort toward achieving zero fatalities and serious injuries must be centered on keeping speeds at levels that account for human injury tolerance.

To address this critical issue of speed, U.S. DOT's *National Roadway Safety Strategy* urges all agencies to adopt the Safe System Approach, a new paradigm in traffic safety management that emphasizes that humans have physiological tolerances to crash forces and that road agencies must create roadways that provide safe speeds and create redundancies to reduce the severity of crashes when they do occur (USDOT 2022a).

This report presented a framework to aid both State and local transportation agencies to develop a Safe System Approach for Speed Management. This framework consists of the following five stages:

1 Establishing a vision and building consensus for speed management

2 Collecting andanalyzing speed and safety data

3 Prioritizing locations for speed management proactively

4 Selecting speed management countermeasures

5 Ongoing monitoring, evaluation, and adjustment

Not every agency will be able to apply every countermeasure discussed throughout this report, and not all agencies will be able to easily adjust posted and statutory speed limits. However, this report provides case studies that demonstrate how agencies have been able to overcome institutional barriers and rally behind Safe System principles to enact speed management programs with proven, measurable reductions in operating speeds and fatal and serious injury crashes.

Readers are encouraged to review the 10 case studies to find examples of successful approaches to lowering speed limits, redesigning roadways, collecting data, enforcing speeds with technologies, and working toward network-wide realizations of target speeds that improve the safety of all road users.

Across the international and domestic documents reviewed for this report and collected through interviews with case study jurisdictions, some key themes emerged, including the following:

- As possible, agencies should attempt to align speed limits and target speeds that prioritize injury minimization, and this alignment often requires changing the roadway environment to slow driver speeds.
- Agencies can use strategic plans, like Vision Zero, to build public will for speed management practices and align those practices with Safe System Approach-based traffic safety goals.
- Agencies should collect relevant speed and safety data to both guide the speed management program and to build public support for the program.

APPENDIX – CASE STUDIES

Case Study A.1. Washington State Injury Minimization and Speed Management —State of Washington, USA

Key Successes

The Washington State Injury Minimization and Speed Management effort is a noteworthy practice that shows an example of a State DOT setting a framework for speed management in jurisdictions.

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** Washington adopted a Target Zero plan in 2019 with the goal to eliminate road fatalities and serious injuries by 2030.
- **Humans make mistakes/humans are vulnerable:** Injury minimization is a priority in the State's Target Zero efforts.
- **Responsibility is shared:** Interagency collaboration and collaboration with neighboring jurisdictions help to achieve speed management and injury minimization.
- **Redundancy is crucial:** Speed management and injury minimization are achieved through engineering, education, and enforcement measures.

Background

In 2019, Washington State adopted the Safe System Approach as part of its SHSP, which embraced the Zero Deaths vision.[1] Speed management is a priority in Washington's Zero Deaths vision, since one in every three fatal crashes in the State between 2015 and 2017 involved speeding as a contributing factor. The plan recognized that speed limit setting through the notion of injury minimization would result in a significant reduction in fatal and serious injuries for all road users, especially pedestrians and bicyclists.

As a result of Washington's Vision Zero efforts, the Washington State Department of Transportation (WSDOT) convened a workgroup including State, local, and Tribal partners to develop a speed management policy and guidelines focused on injury minimization. The policy elements and implementation recommendations were summarized in a document released in October 2020,[2] which emphasizes lower operating speeds based on context on State routes, city streets, county roads, and Tribal roads and that are compatible with the needs of all types of users. The WSDOT workgroup encourages all agencies in the State of Washington to adopt an injury minimization and speed management policy based on the elements outlined in the document.

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1 State of Washington. (2019). *Washington State Strategic Highway Safety Plan 2019: Zero Deaths and Zero Serious Injuries by 2030*. Olympia, WA: State of Washington. Retrieved from http://wtsc.wa.gov/wp-content/uploads/dlm_uploads/2019/10/TargetZero2019Lo-RES.pdf.

2 Washington Department of Transportation. (2020). *Washington State Injury Minimization and Speed Management Policy Elements and Implementation Recommendations*. Olympia, WA: State of Washington. Retrieved from https://wsdot.wa.govsitesdefault/ files/2021-10/InjuryMinimization-SpeedManagement-PolicyElements-Recommendations.pdf.

Implementation

The WSDOT Injury Minimization and Speed Management workgroup studied the findings of multiple reports, scientific papers, legislative statutes, manuals, and recommendation documents to understand and address speed and injury severity. Based on the findings, the workgroup recommended the following elements for an Injury Minimization and Speed Management Policy for all agencies in Washington:

- Adopt and implement an injury minimization speed limit setting approach.
- Adopt a broader Safe System Approach to proactively identify priority locations (locations with higher possibility of serious injury or fatal crashes).
- Consider injury minimization and speed management in all transportation investments and project phases regardless of funding source.
- Collaborate with neighboring jurisdictions.
- Require training on injury minimization and speed management techniques.
- Adopt access control, access management policies, and land use development policies, ordinances, and practices that consider target speeds.
- Adopt a Vision Zero goal.

The Injury Minimization and Speed Management workgroup also provided recommendations to achieve target speeds for practitioners who set speed limits, design engineers, and planners. The workgroup recommended that the process for setting target speeds be an innovative practice that considers the presence of older adults, transit users, youth, pedestrians, bicyclists, and land use. Special consideration is provided for road users who are reliant on transit and active transportation due to income disparities or physical disabilities. A summary of the recommended process to set target speed limits is shown below:

- Establish target speeds based on road and land use context, road user characteristics, potential for different crash types, the impact forces that result from a crash, and the human body's injury tolerance. This may require a phased, step-down approach.
- Use default/category target speed limits for all areas that have the same context, density, and/or road characteristics.
- Where the operating speed is within 5 mph of the target speed, adopt the target speed.
- Where the operating speed exceeds the target speed by 5 mph, use an engineering study to determine iterative speed limits and implement speed management approaches.
- Make incremental adjustments of 5 mph or more as motorists respond to speed management techniques until the target speed is achieved.

In addition to the overall recommendations for injury minimization and speed management in Washington, the workgroup also developed specific information regarding data analysis, education of the public and elected officials, changes to laws and regulations, and enforcement. The workgroup recommended that traffic safety professionals pursue training at all jurisdictional levels in engineering, education, and enforcement.

Outcomes

Although no evaluation of the speed and safety impacts of the injury minimization and speed management recommendations are available, this effort is a noteworthy practice for setting a framework for speed management in jurisdictions.

Additional Information

Setting target speed limits based on factors other than vehicular travel speeds is an emerging approach. On March 25, 2022, Washington State Governor Jay Inslee signed into law Senate Bill 5974.[3] Section 418 of this law states that all State transportation projects starting the design phase on or after July 1, 2022, and that are valued at more than $500,000 must

> *adjust the speed limit to a lower speed with appropriate modifications to roadway design and operations to achieve the desired operating speed in those locations where this speed management approach aligns with local plans or ordinances, particularly in those contexts that present a higher possibility of serious injury or fatal crashes occurring based on land use context, observed crash data, crash potential, roadway characteristics that are likely to increase exposure, or a combination thereof, in keeping with a Safe System Approach and with the intention of ultimately eliminating serious and fatal crashes.*

The law also made several amendments to Washington State law regarding automated traffic safety cameras. For additional information regarding Injury Minimization and Speed Management in Washington, contact Charlotte Claybrooke, WSDOT Active Transportation Programs Manager, at claybrc@wsdot.wa.gov.

[3] State of Washington. (2022). Engrossed Substitute Senate Bill 5974. 67th Legislature. Retrieved from https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session%20Laws/Senate/5974-S.SL.pdf.

Case Study A.2. Video-Based Network-Wide Speed and Speeding Analysis—Bellevue, Washington, USA

Key Successes

The Video-Based Network-Wide Speed and Speeding Analysis project in Bellevue, Washington, developed a video-based network screening methodology to identify locations with high risk for vehicular speeding and improve the city's understanding of the factors contributing to speeding at hot spots. This proactive approach allows the implementation of safety countermeasures before crashes occur.

The Safe System Approach Highlights

- Death/serious injury is unacceptable: Adoption of a Vision Zero resolution in 2015
- Humans make mistakes/humans are vulnerable: Efforts to understand contributing factors to reduce speeding-related fatalities and serious injuries
- Responsibility is shared: Collaborative approach between the City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans – University of Washington
- Safety is proactive: Identifying crash contributing factors (such as speeding) citywide through video-based analysis of near-misses to improve safety conditions before crashes occur
- Redundancy is crucial: Data collection, engineering measures, and enforcement to reduce speeding in Bellevue

Background

The City of Bellevue is in the Eastside region of King County and is the fifth largest city in Washington, with a population of approximately 152,000.[1] Bellevue adopted a Vision Zero resolution in 2015 with the goal of eliminating fatalities and serious injuries on City streets by 2030.[2] The city's focus has been to understand the factors contributing to these fatalities and serious injuries and develop effective countermeasures.

The city partnered with Transoft Solutions (formerly Brisk Synergies), Together for Safer Roads, and PacTrans – University of Washington to conduct a network-level analysis of traffic camera video data to identify locations with high risk of crashes based on near misses. The project used video footage from Bellevue's network of existing traffic cameras, which was processed and analyzed using Transoft Solutions' traffic and road safety technology.[3]

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1 United States Census Bureau. (2020). "2020 Census." Retrieved from https://www.census.gov/programs-surveys/decennial-census/decade/2020/2020-census-main.html.

2 City of Bellevue. (2015). "Resolution No. 9035: A Resolution Endorsing Vision Zero." Retrieved from https://bellevue.legistar.com/LegislationDetail.aspx?ID=2529869&GUID=AC438708-5B2B-40BB-A155-D41457B5DDEF.

3 City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans – University of Washington. (2020). *Video-Based Network-Wide Speed and Speeding Analysis*. Retrieved from https://safety.transoftsolutions.com/resources/.

Together for Safer Roads is a corporate social accelerator that leverages private sector technology, data, and expertise to prevent traffic crashes; the University of Washington was part of the team that had previously launched a pilot video analytics program in Bellevue and contributed to the project by sharing lessons learned. This project is one of three similar efforts conducted through this partnership; the other two are the Video-Based Network-Wide Conflict Analysis project[4] and the Video-Based Conflict, Speeding, and Crash Correlation project.[5]

Implementation

The Video-Based Network-Wide Speed and Speeding Analysis in Bellevue was a large scale network screening project using video data from traffic surveillance cameras and TrafxSAFE (previously identified as BriskLUMINA), a specialized automated-road-safety platform developed by Transoft Solutions. The project evaluated 40 signalized intersections, mostly outside of the downtown area, including 34 four-legged intersections, 5 three-legged intersections, and 1 five-legged intersection. The intersections were selected to represent different geographic locations, land uses, population density, and road geometry. All intersections have a posted speed limit of 30 or 35 mph, except for the Bel-Red Road and NE 30th Street intersection, which had a 40-mph posted speed limit.

Traffic cameras at the study intersections recorded daily for 16 hours (from 6 a.m. to 10 p.m.) for the months of August and September in 2019. Road user counts, operating speeds, and near-miss data was derived from the processing of the video footage. To understand factors contributing to speeding, statistical models that included the following variables were developed by Transoft Solutions:

- Urban density (high or medium)
- Land use (commercial or residential)
- Presence of school within less than 0.125 miles from the intersection
- Road user types (car driver, bus or truck operator, motorcyclist)
- Road user movement (through, left turn, or right turn)
- Vehicular traffic phasing (protected vs. non-protected left turns)
- Pedestrian traffic phasing
- Traffic volumes
- Number of lanes
- Lane width
- Crosswalk width
- Presence of bike infrastructure (dedicated bike path, shared bike path, both, or neither)
- Time of the day
- Day of the week

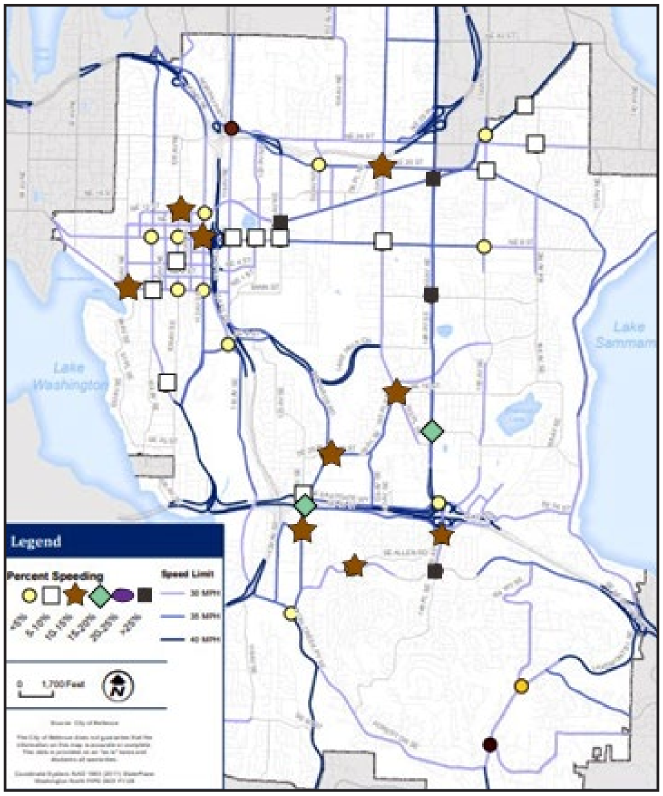
[4] City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans – University of Washington. (2020). *Video-Based Network-Wide Conflict Analysis*. Retrieved from https://brisk-cdn.s3.amazonaws.com/www/articles/2020-07-05/VZ-ITS-Bellevue-Report-1-web.pdf.

[5] City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans – University of Washington. (2020). *Video-Based Conflict, Speeding, and Crash Correlation*. Retrieved from https://brisk-cdn.s3.amazonaws.com/www/articles/2020-07-05/VZ-ITS-Bellevue-Report-3-web.pdf.

Outcomes

The evaluation of video footage in Bellevue resulted in the following network-wide findings:

- Vehicular speed was higher in residential locations than in commercial locations.
- Vehicular speeds were higher at intersections outside of the downtown area.
- Vehicular speeds were higher on the weekend.
- Approximately 11 percent of drivers were speeding. Driver speeding incidence was higher in the downtown area.
- Motorcyclists were the fastest motorized road users.
- There was a decrease in vehicular speeding during peak hours.
- The video-based network screening allowed the development of a map showing the percentage of motorists speeding (**Figure 4**).



Source: City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans.

Figure 4. Percentage of motorists speeding.

An in-depth analysis was conducted at the intersection of Bel-Red Road and NE 30th Street, the study intersection most prone to vehicular speeding. The four-legged intersection includes a small traffic island separating the westbound right-turning movements and another island for southbound left-turning drivers. No northbound left-turn, eastbound left-turn, eastbound through, and westbound through movements are permitted at the intersection (**Figure 5**). In addition, pedestrian volumes are low at the intersection.

Source: City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans – University of Washington.

Figure 5. Bel-Red Road and NE 30th Street in Bellevue.

Source: City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans – University of Washington.

Figure 6. Speed heatmap at the Bel-Red Road and NE 30th Street intersection.

The analysis of the Bel-Red Road and NE 30th Street intersection, which had the highest risk for motorist speeding, resulted in the following insights:

Northbound and southbound through speeds were high (**Figure 6**). Only two through movements are allowed at this intersection, which are along the North-South corridor, where traffic volumes are significantly higher. Additionally, only one left turn is permissible along this corridor, and it is protected by a traffic island. Speeding at this intersection can be attributed to the excessive confidence of drivers because of the lower volumes of surrounding movements and the prohibition of several other movements. The speeding behavior is similar to that of drivers increasing their speeds to catch the end of a green or yellow traffic light (**Figure 7)**.

Source: City of Bellevue, Transoft Solutions, Together for Safer Roads, and PacTrans – University of Washington.

Figure 7. Through driver speeding to cross red light.

All right turning movements had similar speeds except for the northbound right-turning movement. This can be attributed to the wider turning radius available for this movement compared to the other right-turning movements.

The Video-Based Network-Wide Speed and Speeding Analysis demonstrates the scalability of the network screening methodology to identify locations with high risk for vehicular speeding and understanding factors contributing to speeding at hot spots. This approach allows the implementation of safety countermeasures before crashes occur, and this analytics solution can support Vision Zero programs. The City of Bellevue plans on implementing safety countermeasures at high- risk locations identified with this network screening methodology in the near future.

Additional Information

In addition to the Video-Based Network-Wide Program to identify speeding contributing factors, the City of Bellevue has several speed management programs. The city has slowly started rolling out 20 mph neighborhood speeds through its Neighborhood Slow Zone program and recently updated its Standard Operating Procedures for evaluating existing speed limits based on the latest information from NCHRP and NACTO. The city's Neighborhood Traffic Safety Services group works with residents to discourage speeding near schools by installing permanent speed feedback signs and school zone flashing beacons in the vicinity of schools. To support speeding concerns in neighborhoods, the city has a program that allows residents to request temporary speed feedback signs, special police speed enforcement, use of a radar gun to do an evaluation of speed concerns, and lawn signs that encourage safe speeds. For additional information, contact Franz Loewenherz, City of Bellevue Mobility Planning and Solutions Manager, at Floewenherz@bellevuewa.gov.

Case Study A.3. 2020 Vision Zero: Speed Management—Fremont, California, USA

Key Successes

The city of Fremont, California, adopted a Vision Zero policy in 2015. Fremont's efforts to reduce vehicular speeds resulted in the following safety outcomes (comparing average crashes between 2013 to 2015 with average crashes between 2018 and 2020):

- A 45 percent decrease in fatal and serious injury crashes across all modes
- A 44 percent decrease in crashes involving speeding

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**: The policy focuses on reducing vehicular speeds to lower crash impact forces.
- **Responsibility is shared**: Vision Zero is a coordinated effort that involves 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 policy used a systemic approach to implement speed limit reduction, enforcement, and to reduce vehicular travel-lane width.
- **Redundancy is crucial**: Engineering (street redesign), enforcement, and education (community outreach) measures are part of Fremont's efforts to reduce vehicular travel speeds.

Background

The City of Fremont is located in the Silicon Valley area of Northern California and has a population of 240,000. From 2013 through 2015, Fremont experienced a concerning rise in traffic fatalities and serious injury crashes. The city's organizational focus on traffic safety began in 2015 with the adoption of a Vision Zero policy, followed by an action plan in 2016.[1] Prior to 2015, 70 percent of fatal and serious injury crashes in Fremont happened on streets with a speed limit of 40 mph or higher.

City staff from the Police Department and the Public Works Department prepared a data-driven, fully collaborative action plan for year 2020. As part of the effort to eliminate fatal and serious injury crashes, the City of Fremont has applied a Safe System Approach to street design, operations, and public education.

[1] City of Fremont. (2017). Fremont Vision Zero 2020:. Retrieved from https://mtc.ca.gov/sites/default/files/Fremont_Vision_Zero.pdf.

Implementation

Fremont's approach to Vision Zero includes modifying organization practices, forming partnerships, using data for high-impact work, updating plans and community engagement, and implementing safety improvements. The City of Fremont's Transportation Engineering, Pavement Maintenance Program, and Street Maintenance are all organized within the public works department, which reduces barriers to collaboration. Further, the collaboration between the police department, fire department, and public works department resulted in the following:

- Crash locations and near miss locations are evaluated for countermeasures.
- Project planning and design of streets is collaborative to ensure emergency response times are not affected.

The City of Fremont Public Works Department conducts data analysis that includes regular and timely monitoring of detailed crash narratives and reports (in coordination with the police department), mapping of the high-injury network, and recommending both hot spot and systemic countermeasures. Community engagement occurs through task forces before any safety improvements are implemented. The city's actions to reduce vehicular speeds and improve safety are summarized below:

- **Safe and Complete Streets**: Fremont has adopted a 10 ft travel lane standard, which creates a feeling of greater enclosure and friction for drivers and encourages slower speeds. Since 2015, the City of Fremont restriped approximately 50 percent of its arterial roadways, reducing lane widths from 12–14 ft to 10 ft (Figure 8).

Source: City of Fremont.

Figure 8. Striped median to reduce lane widths in Fremont.

- **Safe neighborhoods:** Fremont has undertaken measures to ensure safe speeds in neighborhoods. The city increased the number of speed humps from 200 to 250 citywide between 2018 and 2020.

- **Speed management:** After engineering streets for safer speeds, the City of Fremont re-surveys streets to assess whether projects resulted in lower operating speeds. Fremont has lowered the posted speed limit on more than 50 street segments, comprising more than 20 roadway miles.
- **Community outreach**: The City of Fremont has launched a "Drive Slowly, Be Healthy" campaign to manage speeds during the national events of 2020 and beyond. The campaign includes 20 mph advisory speeds on all neighborhood streets.
- **Hot spot response:** In addition to implementing systemic improvements (e.g., quick-build crosswalk improvements and installation of pedestrian countdown signals) to prevent future crashes, Fremont implemented improvements in response to crash hot spots. For example, Grimmer Boulevard was a hot spot for fatal and serious injury crashes before 2016. The city restriped the roadway with narrower 10 ft lanes and a buffered bike lane and installed a concrete k-rail in the bike buffer.

Outcomes

The City of Fremont conducted speed surveys on approximately 100 street segments citywide in 2020, in advance of its typical 7-year cycle for citywide speed surveys. In 2021, the city released a safety status report comparing average crashes between 2013 to 2015 (before the Vision Zero policy) with average crashes between 2018 to 2020 (after the Vision Zero policy).[2] Impacts on crashes included a 45 percent reduction in the number of fatal and serious injury crashes across all modes and a 44 percent decrease in total crashes involving speeding. In addition, no fatal and serious injury crashes have occurred along Grimmer Boulevard—previously a hot spot—since the safety improvements were installed.

Additional Information

The City of Fremont achieved its Vision Zero accomplishments with no new city funding commitments and no new dedicated staff positions. The program entailed reallocating existing funding resources away from projects that did not serve Vision Zero goals and shuffling existing staff assignments. The City of Fremont redirected $2.5 million in funding that was not aligned with the "safety first" policy, which allowed work to start immediately rather than be delayed by the regular budget allocation process.

The City of Fremont's next plan includes actions such as encouraging State legislation for safer speeds by enabling speed safety cameras, as well as continuing local actions for safer streets by managing speeds using signal timing and enforcement. For additional information, contact Hans Larsen, City Public Works Director (hlarsen@fremont.gov).

[2] City of Fremont, CA. (2021). *Fremont Vision Zero: Status Report + 2025 Action Plan*. Retrieved from: https://www.fremont.gov/home/showpublisheddocument/759/637750212463000000.

Case Study A.4. Automated Speed Enforcement—Montgomery County, Maryland, USA

Key Successes

The effects of the automated speed enforcement in Montgomery County, Maryland, resulted in the following outcomes:

- A 100 percent reduction in mean speeds due to the speed cameras.
- A 62 percent reduction in the likelihood that a vehicle was traveling more than 10 mph above the speed limit at camera sites.
- A 19 percent reduction in the likelihood that a crash resulted in fatality or serious injury due to speed cameras alone. Along the speed camera corridors (cameras were periodically moved along the length of a roadway segment), speed cameras were associated with an additional 30 percent reduction in the likelihood that a crash resulted in a fatality or serious injury.

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** Montgomery County adopted Vision Zero in 2016.
- **Humans make mistakes/humans are vulnerable:** The county's automated speed enforcement program focuses on vehicular speed reduction, which can lead to reduced crash severity, especially for vulnerable road users.

Background

Montgomery County is the most populous county in the State of Maryland, with a population of approximately 1 million. The County has multiple programs aimed at lowering operating speeds to match the roadway and land use context, including their Safe Speed Program (automated speed enforcement). Placement of automated traffic cameras are legislated under Maryland Traffic Article 21-809.[1] Automated speed enforcement in Montgomery County was implemented in 2007. In 2009, the State speed camera law increased the enforcement threshold from 11 to 12 mph over the speed limit and restricted school zone enforcement hours. In 2012, Montgomery County began using a corridor approach, in which cameras were periodically moved along the length of a roadway segment.

Implementation

The county introduced automated speed enforcement in 2007, and early research found that more than 60 percent of residents supported the program after it started.[2] In Montgomery County, local law enforcement can place speed cameras on a residential road with a speed limit of 35 mph or less or within a designated school zone.

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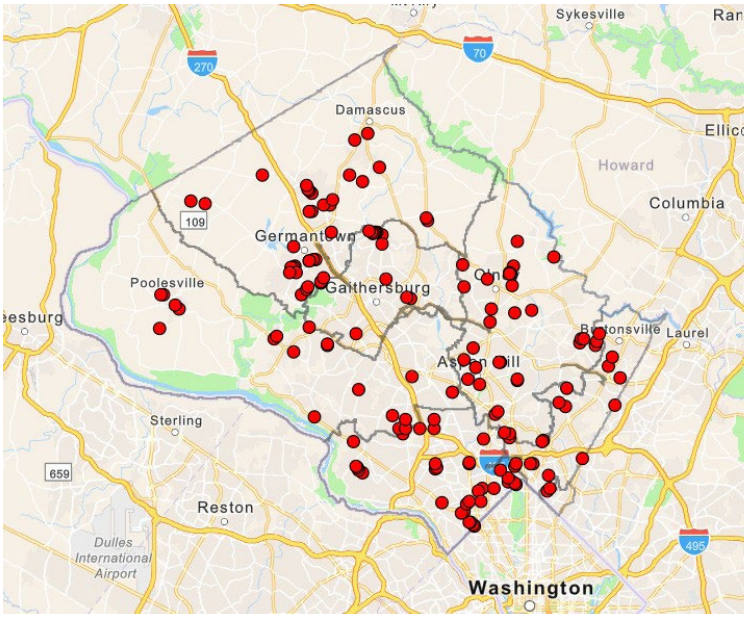
1 Montgomery County. (2022). "Speed Camera Placement." Retrieved from https://www.montgomerycountymd.gov/ pol/howdoI/request-speed-camera.html.

2 Insurance Institute for Highway Safety. (2008). *Evaluation of Automated Speed Enforcement in Montgomery County, Maryland*. Retrieved from https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa1304/resources/Evaluation%20of%20ASE%20in%20Montgomery%20County,%20MD.pdf.

The process for placing and evaluating speed cameras in Montgomery County uses a data-driven approach. The process for installing speed cameras in the county follows the following steps:

1. **Identify camera location:** The request to initiate evaluation for speed camera installation can be made by residents, homeowners associations, police officers, government officials, and police department traffic division personnel. Potential camera locations can also be identified based on crash data, site surveys, pedestrian activity, community and environmental concerns, and points of interest in the area.
2. **Data collection:** Vehicular speeds are collected along stretches of the roadway with speeding concerns.
3. **Data analysis:** Data is analyzed and reviewed by automated traffic enforcement unit personnel, the safe speed program manager, and the director of the police department's traffic division.
4. **Field observations:** After a potential location for camera installation is identified, a field visit is conducted to evaluate the following site characteristics: location (residential, school zone, or commercial), roadway grade, presence of speed limit signs, crash frequency, traffic volumes, environmental factors (areas where the equipment can be safely set up, operated, and maintained), pedestrian proximity to a potential speed enforcement location (existence of schools, bus stops, playgrounds, pools, sidewalks, retirement facilities, crosswalks, and other pedestrian generators).
5. **Final approval:** The director of the traffic division has final approval. Once final approval is given, the site must be advertised in a newspaper of general circulation prior to conducting enforcement.



Source: Montgomery County.

Figure 9. Montgomery County safe-speed camera locations (outside of Speed Camera Corridors).

As of 2019, there were 152 speed cameras (**Figure 9)** in Montgomery County.[3] The county constantly evaluates driver behavior near the speed camera locations. With the increased driver familiarity with camera locations, Montgomery County noticed that drivers generally slowed down when approaching a known speed camera and accelerated once they had passed it. To mitigate this driver behavior, the Montgomery County Police Department initiated a corridor approach in 2012, which allows for the placement of cameras anywhere within a designated speed camera corridor.[4] The cameras along the speed camera corridor change locations regularly. The county adopted the speed camera corridor approach to have drivers reduce speeds on an entire stretch of road rather than just where they know the cameras are located.

Outcomes

A study conducted in 2016 evaluated the effects of automated speed enforcement in Montgomery County on vehicle speeds, public opinion, and crashes.[5] The study found that speed cameras were associated with a 10 percent reduction in mean speeds. The study also found a 62 percent reduction in the likelihood that a vehicle was traveling more than 10 mph above the speed limit at camera sites.

Further, the overall effect of the camera program in its modified form was a 39 percent reduction in the likelihood that a crash would result in an incapacitating or fatal injury. Speed cameras alone were associated with a 19 percent reduction in the likelihood that a crash would result in fatality or serious injury. At the speed camera corridors, where cameras would be moved so that people did not slow for only one location, speed cameras were associated with an additional 30 percent reduction in the likelihood that a crash resulted in a fatality or serious injury.

Additional Information

Montgomery County adopted Vision Zero in 2016 with the goal of eliminating fatal and serious injuries on county roads by 2030. Under the Vision Zero 2030 Action Plan, work plans are updated every even year to make continual progress on all action items. The 2022-2023 Vision Zero work plan includes the following safe speeds action items: examine speed limit on all projects, speed management policy, and enforcement of speed limits.[6] For further information regarding speed enforcement in Montgomery County, contact Captain Jim Brown, Montgomery County Traffic division director, at POLTrafficDivisionDirector@montgomerycountymd.gov.

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3 Montgomery County. (2019). Safe Speed Camera Locations. Retrieved from https://www.montgomerycountymd.gov/pol/howdoI/speed-camera-locations.html.

4 Montgomery County. (2022). Speed Camera Corridor Camera Locations. Retrieved from https://www.montgomerycountymd.gov/pol/Resources/Files/speed-camera/SpeedCameraLocations2020.pdf.

5 Hu W, McCartt AT. (2016). "Effects of Automated Speed Enforcement in Montgomery County, Maryland, on Vehicle Speeds, Public Opinion, and Crashes," *Traffic Injury Prevention* 17(1):53–8. https://doi.org/10.1080/15389588.2016.1189076.

6 Montgomery County. (2022). *Vision Zero: Fiscal Years 2022-23 Work Plan*. Retrieved from https://www.montgomerycountymd.gov/visionzero/Resources/Files/FY22-23_Vision_Zero_Workplan.pdf.

Case Study A.5. New York City's Speeding Solutions Toolkit—New York City, New York, USA

Key Successes

New York City's speed management toolkit uses a variety of approaches, including speed limit reduction, school zone automated enforcement, police enforcement, installation of speed humps and speed cushions, reduced vehicular travel lane widths, intersection turn calming, and community outreach. New York City's efforts to reduce speeds and improve safety resulted in the following outcomes:

- Speeding at fixed camera locations in school zones has dropped 72 percent.
- Crashes with injuries, considering all road users, decreased by 8 percent on speed camera corridors in school zones.
- Injuries resulting from bicycle and pedestrian crashes with children decreased by 20 percent on speed camera corridors in school zones.
- Injuries at speed-hump locations decreased by 9 percent.
- Injuries at speed-cushion locations decreased by 17 percent.
- Pedestrian fatalities and serious injuries decreased by 28 percent after road diet projects.
- Pedestrian fatalities and serious injuries decreased by 33 percent after intersection turn calming improvements.

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** The city adopted Vision Zero in 2014.
- **Humans make mistakes/humans are vulnerable:** The city introduced speed reduction measures to reduce impact forces of a crash.
- **Responsibility is shared:** The effort entailed collaboration between New York City departments and local agencies and organizations.
- **Safety is proactive:** The approach enacted a citywide speed limit reduction.
- **Redundancy is crucial:** Engineering, enforcement, and education measures were adopted to reduce vehicular speeds.

Background

New York City adopted a Vision Zero policy in 2014, with a collaborative action plan involving the City Hall, Police Department, Department of Transportation, Taxi and Limousine Commission, Department of Citywide Administrative Services, and Department of Health and Mental Hygiene.[1] At the time, road crashes in New York City resulted in approximately 250 fatalities and 4,000 serious injuries each year, and 70 percent of pedestrian fatalities involved driver behavior, such as inattention, speeding, and failure to yield. As a result, speed management was identified as a focus area for the city's Vision Zero efforts, and a toolkit of speeding solutions was implemented to improve safety.

[1] City of New York. (2014). *Vision Zero Action Plan*. Retrieved from https://www.nyc.gov/html/visionzero/pdf/ nyc-vision-zero-action-plan.pdf.

Implementation

New York City's Speeding Solutions Toolkit uses a variety of approaches, including speed cameras, installation of speed bumps, focused enforcement, signal reprogramming, reduced speed limits, and street redesigns.

- **Speed limits:** In 2014, New York City Department of Transportation (NYC DOT) reduced the citywide default speed limit to 25 mph and installed more than 5,000 new speed limit signs in combination with camera-based speed enforcement (**Figure 10**). Further, NYC DOT reduced the speed limit by 5 mph on more than 70 miles of arterial corridors.
- **School zone automated enforcement:** In 2013, New York State enacted Section 1180-b of New York State's Vehicle and Traffic Law (VTL), which allowed New York City the authority to pilot an automated speed enforcement program in 20 school speed zones. New York City has since then enacted legislation to expand the use of automated enforcement and currently has speed cameras installed in 750 school speed zones. Camera installation is prioritized at locations with the highest incidence of speeding and serious crashes involving pedestrians. State law prohibits New York City from using the speed camera program to issue violations for speeding unless it is observed within a quarter- mile radius of a school building between the hours of 6 AM and 10 PM on a weekday.
- **Police enforcement:** Traditional speeding enforcement is also a tool to reduce vehicular travel speeds in New York City.
- **Speed humps and cushions:** New York City installed almost 2,200 speed humps and 40 speed cushions between 2014 and 2020.

Source: City of New York.

Figure 10. Speed limit sign used in combination with automated enforcement.

- **Street Improvement Projects (SIP) program:** New York City's SIP program prioritizes safety improvements at locations with high rates of serious pedestrian injuries and fatalities. Some of the program countermeasures are related to speed reduction, such as roadway redesign and turn calming (**Figure 11**). Roadway redesign is conducted by reducing vehicular travel lane width or converting a vehicular lane to use for pedestrians and cyclists. Turn calming is implemented by adding markings, plastic bollards, and/or rubber speed bumps that slow and control vehicular turns.

Before **After**

Source: NYC DOT.

Figure 11. Lincoln Center Bowtie Street improvements included reduced lane width and turn calming.

- **Community outreach:** Along the most crash prone corridors in New York City, the New York City Police Department (NYPD) and NYC DOT Street Teams combined education and enforcement. The NYC DOT Street Teams inform a specific community about safety and Vision Zero efforts while increased enforcement of traffic violations is conducted by NYPD.
- **Education:** NYC DOT public education campaigns have a particular emphasis on speeding and are disseminated through television, radio, billboards, and bus stop advertisements.

Outcomes

A before-after analysis was conducted to evaluate speeding and safety outcomes at fixed school zone camera locations in New York City between 2014 and 2020.[2] The study found that speeding at fixed school zone camera locations dropped 72 percent. Further, the analysis showed a 3 percent reduction in total crashes and an 8 percent reduction in crashes with injuries, considering all road users. The study also showed that there was an approximately 20 percent reduction in injuries resulting from bicycle and pedestrian crashes with children.

Safety outcomes from installing speed humps and speed cushions were also investigated. A before-after analysis in New York City showed a 9 percent reduction in injuries at 1,637 speed hump locations (between 2008 and 2015) and a 17 percent reduction in injuries at 9 speed cushion locations (between 2017 and 2021).[3]

NYC DOT employed a before-after injury analysis comparing the average year of crash data before SIP treatment installation to the average year of crash data after installation, with a focus on pedestrian fatalities and injuries.[4] The safety outcomes for speeding-related treatments are as follows:

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[2] City of New York (2020). *New York City Automated Speed Enforcement Program: 2014-2020 Report*. Retrieved from https://www1.nyc.gov/html/dot/downloads/pdf/speed-camera-report.pdf.

[3] Information provided by the New York City Department of Transportation for this case study.

[4] Ibid.

- Road diets: 28 road segments (29.12 miles) were evaluated and demonstrated a 28 percent reduction in pedestrian fatalities and serious injuries.
- Turn calming: The evaluation of 107 intersections before and after turn-calming treatments showed a 33 percent reduction in pedestrian fatalities and serious injuries.

Additional Information

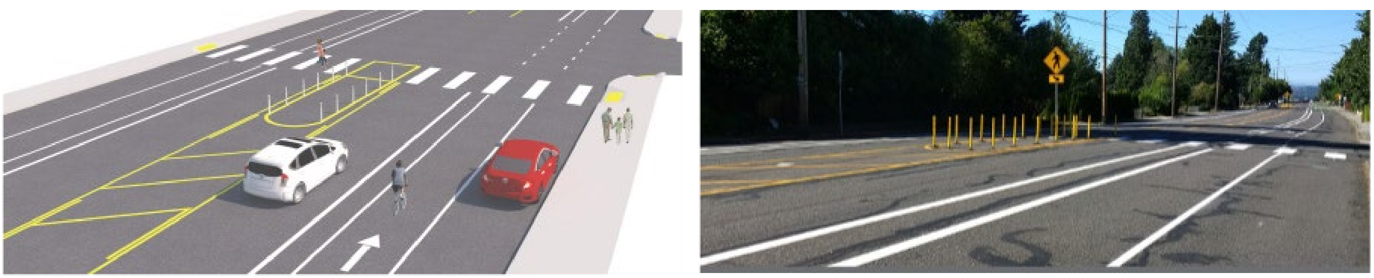
From 2014 to 2020 (fiscal year), the speed camera program in New York City school zones had $155,779,314 in operating costs and $94,588,548 in capital costs. For more information regarding New York City's speed management efforts, contact Rob Viola, Director of Safety Policy and Research at the NYC Department of Transportation, at RViola@dot.nyc.gov.

Case Study A.6. Multi-Disciplinary Approach for Speed Reduction Citywide—Portland, Oregon, USA

Key Successes

The multi-disciplinary approach for speed reduction citywide in Portland included strategies such as residential speed limit reduction, an alternative methodology to setting speed limits, street redesign, intersection left turn calming, automated speed enforcement, and community outreach and education. The key successes from the city's efforts to reduce vehicular speeds are shown below:

- A 34 percent reduction in the odds of observing speeds greater than 30 mph on residential streets
- A 50 percent reduction in the odds of observing speeds greater than 35 mph on residential streets
- Development of an alternative methodology for setting speed limits in Portland that considers vehicles, pedestrians, and bicyclists
- Street redesign (**Figure 12**) resulted in a reduction in vehicle speeds with no significant changes to travel times along the main corridor and no significant changes to volumes or speeds on nearby neighborhood streets



Source: PBOT.

Figure 12. Example of road configuration in Portland after street redesign from five lanes to three lanes.

- A 13 percent reduction in vehicular turning speeds due to left turn calming
- A 71 percent reduction in speeding over the speed limit due to automated enforcement
- A 94 percent reduction in top end speeding due to automated enforcement

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** The City adopted Vision Zero in 2015.
- **Humans make mistakes/humans are vulnerable:** Vision Zero efforts prioritize vehicular speed reduction in Portland.
- **Redundancy is crucial:** The city's multidisciplinary approach to reducing speeds includes engineering, enforcement, and education efforts.

Background

The City of Portland is the county seat of Multnomah County and is the largest city in the State of Oregon, with a population of approximately 653,000. Portland committed to Vision Zero in 2015 and released an action plan in 2016.[1] The Portland Bureau of Transportation (PBOT) has applied Safe System principles to update speed limits on nearly all streets citywide since 2017, as allowed by State law, and reduced the residential street speed limit from 25 mph to 20 mph in 2018. More than 90 percent of non-freeway streets in Portland have speed limits no higher than 30 mph, in accordance with the World Health Organization's best practices for urban areas. PBOT continues to update and evaluate the impact of speed limit reduction and pursues complementary speed management practices, including signal retiming, road restriping that accommodates buffered bike lanes, and traffic calming to reinforce posted speeds.

Implementation

As part of its Vision Zero efforts, the City of Portland adopted a multi-disciplinary approach for speed reduction citywide. The main strategies to lower speeds and reduce the chance of death or serious injury are summarized below:

- **Residential speed limit reduction:**[2] The City reduced speed limits from 25 mph to 20 mph on most residential streets in 2018. Approximately 76 percent of non-freeways in Portland have a 20 mph posted speed limit.
- **Setting target speeds:**[3] In 2016, PBOT submitted a request to ODOT to use an alternative methodology[4] for speed zones on non-arterial roads with posted speed limits greater than 25 mph. The City's proposed methodology for setting speed limits incorporates the needs of all road users by focusing on the safety of VRUs. PBOT worked with ODOT to create a process in which PBOT submits a formal request to ODOT to lower the speed limit for each roadway section in question. The investigation method includes information on the street context, including land use, facilities for pedestrians and bicyclists, crash history, and recommended speed limits based on the Simplified Decision Matrix (**Figure 13**). In 2020, ODOT adopted revised statewide speed limit setting rules for urban areas to incorporate the alternative method's more balanced consideration of safety for all users and reduced reliance on vehicular speed distribution data.

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1 City of Portland (2016). *Vision Zero Action Plan: Saving Lives with Safe Streets*. Retrieved from https://www.portland.gov/sites/default/files/2020-04/vision-zero-action-plan.pdf.

2 City of Portland (2022). "Speed Limits." Retrieved from https://www.portland.gov/transportation/vision-zero/speed-limits.

3 National Transportation Safety Board (2017). *Reducing Speeding-Related Crashes Involving Passenger Vehicles*. NTSB/SS-17/01. Retrieved from https://www.ntsb.gov/safety/safety-studies/Documents/SS1701.pdf.

4 PBOT (2016). *Request to Use an Alternative Methodology for Speed Zones*. Retrieved from https://bikeportland. org/wp-content/uploads/2016/08/PDX_AlternativeSpeedZone_packet-2.pdf.

Street and limits:		Street							
Advisory		Statutory							
Speed	10 mph	≤15	≤20	≤25	≤30	≤35	≤40	≤45	≤50
PED	Shared roadway			5′ sidewalk 100% one side	Sidewalk both sides; curb or swale; 8′ separation	>8′ separation both sides NCHRP 562 crossings: 20/Hr.	>12′ separation both sides	Impermeable separation barrier	
BIKE	Shared roadway			≤ 5′ bike lane	6′ – 7′ bike lane	Minimum 2′ separation from autos	Permeable barrier	Impermeable separation barrier	
AUTO	Gravel roadway	≤ 9′ travel lanes	10′ travel lanes, greenway	10′ travel lanes		≤ 11′ travel lanes; Angle crash mitigations	Permeable center barrier; Roadside object setback or shielding		Impermeable center barrier

Source: PBOT.

Figure 13. Simplified speed limit matrix for fatal crash reduction by mode.

- **Street redesign:** One example of street redesign to lower speeds is the NE 102nd Avenue safety project.[5] NE 102nd Avenue was a high speed, High Crash Network corridor where pedestrian safety was a concern.[6] One of the primary goals of the safety project was to reduce vehicular speeds along the corridor. The project design included a road diet that reduced the roadway from five to three vehicular travel lanes, lowered the speed limit to 30 mph, and installed improvements for pedestrians and bicyclists.
- **Intersection left turn calming**: Approximately 20 percent of pedestrian crashes in Portland result from left turning drivers failing to yield to pedestrians in the crosswalk at signalized intersections.[7] Portland piloted a left turn calming project[8] in 2019 using a combination of rubber bumps, delineator posts, and thermoplastic striping at 42 signalized intersections.
- **Automated speed enforcement**: Oregon allows Portland to use speed safety cameras on its High Crash Network streets. The city's eight fixed speed safety cameras were installed between 2016 and 2018.
- **Community outreach and education**: Portland has a citywide Struck Speed Campaign[9] to inform citizens of the risk of death and serious injuries due to high speeds.

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5 Portland Bureau of Transportation. (2020). *NE 102nd Ave Safety Project Pilot Evaluation Report*. Retrieved from https://www.portland.gov/sites/default/files/2020-06/102nd-evaluation-report-jan-2020_0.pdf.

6 City of Portland. (2022). "High Crash Network Streets and Intersections." Retrieved from https://www.portland. gov/transportation/vision-zero/high-crash-network.

7 City of Portland. (2022). "Left-Turn Calming." Retrieved from https://www.portland.gov/transportation/vision-zero/ left-turn-calming.

8 Portland Bureau of Transportation. (2020). *Evaluation Report: Left Turn Calming Pilot Project*. Retrieved from https://www.portland.gov/sites/default/files/2020-07/left-turn-calming-evaluation-report.pdf.

9 City of Portland. (2022). Struck Traffic Safety Campaign. Retrieved from https://www.portland.gov/transportation/vision-zero/struck.

Outcomes

PBOT does not have available crash data after the implementation of speed reduction measures and, therefore, the outcomes are measured in terms of impacts on vehicular speeds.

- **Residential speed limit reduction**: A study conducted to determine the impact on vehicular speeds following the residential speed limit reduction from 25 mph to 20 mph found a 34 percent reduction in the odds of observing speeds greater than 30 mph and a 50 percent reduction in the odds of observing speeds greater than 35 mph.[10]
- **Setting target speeds**: In 2021, a segment of West Burnside Street was the first street in Portland to get a new speed limit under the alternative methodology for setting speed limits. A before-after analysis of impacts on vehicular speeds and crashes is not available.
- **Street redesign**: The before-after evaluation of the NE 102nd Avenue corridor showed a reduction in vehicle speeds and no significant changes to travel times. Further, there were no significant changes to volumes or speeds on nearby neighborhood streets.
- **Intersection left turn calming**: An evaluation of the pilot left turn calming project showed reduction of overall vehicular turning speeds by approximately 13 percent.
- **Automated speed enforcement**: Since the speed safety cameras were installed, speeding over the speed limit has dropped 71 percent and top-end speeding (more than 10 mph over the speed limit) has dropped 94 percent.[11]

Additional Information

Moving forward, all new High Crash Network capital projects in Portland will include project components that help achieve safe speeds. Further, the City is expanding left-turn calming to locations where permissive turns present risks to pedestrians. An important item to note is that Portland considers equity in speed safety camera placement so that cameras are not concentrated in any one community, and it also has options to tier camera fines based on family income and ability to pay. For further information, contact Matthew Kelly, Vision Zero Specialist at the Portland Bureau of Transportation, at matthew.kelly@portlandoregon.gov.

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[10] Portland State University. (2020). *Effect of Residential Street Speed Limit Reduction from 25 to 20 mph on Driving Speeds in Portland, Oregon*. Retrieved from https://www.portland.gov/sites/default/files/2020/pbot-20-mph-speed-study-finalv5.pdf.

[11] Portland Bureau of Transportation. (2020). *Legislative Report – Outcome Evaluation: Fixed Photo Radar System City of Portland 2019-2020*. Retrieved from https://www.oregonlegislature.gov/citizen_engagement/Reports/Fixed%20Photo%20Radar%20System_Portland%202019-20_FINAL.pdf.

Case Study A.7. Seattle Systemic Speed Limit Reduction—Seattle, Washington, USA

Key Successes

The Seattle Department of Transportation (SDOT) implemented a systemic speed limit reduction program by modifying existing speed limit signs and by increasing speed limit sign density (**Figure 14**). Overall, the impacts of speed limit reductions on speed and safety in Seattle include the following:

- A 22 percent reduction in all crashes and an 18 percent reduction in injury crashes
- A 10 percent reduction in 50th percentile speeds and a 7 percent reduction in 85th percentile speeds
- A 54 percent reduction in the number of vehicles traveling at 40 mph or faster

Source: City of Seattle (2020). 35th Avenue SW Road Safety Corridor Project.

Figure 14. New speed limit sign on Greenwood/Phinney Avenue North.

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** The city adopted a Vision Zero Plan in 2015 to eliminate deaths and serious injuries by 2030.
- **Humans make mistakes/humans are vulnerable:** Reduction of speeds lower the impact forces during a crash, which lowers the crash severity.
- **Responsibility is shared:** The speed limit reduction program involves the city and external agency partners.

- **Safety is proactive:** The implementation of the speed limit program is systemic, including all arterial streets in the city.
- **Redundancy is crucial:** Prior to the systemic reduction on speed limits, the city implemented engineering (street redesign, signal timing changes) and enforcement speed reduction measures.

Background

One of the key elements of the City of Seattle's Vision Zero program is reducing vehicular travel speeds to lower the risk of a fatal or serious injury crash.[1] Prior to setting target speeds citywide, the city implemented pilot projects. The Safe System Approach in Seattle emphasizes engineering measures to support the lower speed limits. The chronological development of Seattle's efforts to reduce vehicular speeds is summarized below:

- **Street design:** In 2015, the city redesigned several streets by converting them from four-lane to three-lane roads. Examples included Rainier Avenue South and 35th Avenue SW.[2, 3] Rainier Avenue South was one of the first corridors where the city piloted the USLIMITS2 speed limit setting approach to set the speed limit to 25 mph.[4]
- **Signal timing:** In 2016, the city retimed the downtown traffic signals and set the speed limit to 25 mph.
- **City Municipal Code:** In 2016, Seattle went through the process of revising the Seattle Municipal Code to lower the default arterial and non-arterial speed limits to 25 mph and 20 mph, respectively (from 30 mph and 25 mph).[5]
- **Urban Villages:** In 2018 and 2019, the city shifted its focus to urban villages, where 80 percent of crashes involved pedestrians.[6] A 25 mph speed limit was established for streets within the urban villages, and a speed limit sign-spacing standard was developed. The 25 mph speed limit was based on operating speeds (to prioritize buses and people walking or biking; buses operate at 25 mph) and the USLIMITS2 (50th percentile speed). After completing efforts for several urban villages and collecting data, a justification for target speeds was formed.
- **Speed limit policy:** From 2020 to 2021, the city developed a new speed limit policy and placed speed limit signs on every arterial street. Approximately 90 percent of Seattle's arterial network has a posted speed limit of 25 mph.

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1 City of Seattle. (2015). *Vision Zero: Seattle's Plan to end Traffic Deaths and Serious Injuries by 2030*. Retrieved from http://www.seattle.gov/documents/Departments/beSuperSafe/VisionZeroPlan.pdf.

2 City of Seattle (2022). "Rainier Improvements." Retrieved from https://www.seattle.gov/visionzero/projects/rainier-ave-s.

3 City of Seattle. (2020). "35th Avenue SW Road Safety Corridor Project." Retrieved from http://www.seattle.gov/ visionzero/projects/35th-ave-sw.

4 Federal Highway Administration. (2020). *USLIMITS2: Tool to Aid Practitioners in Determining Appropriate Speed Limit Recommendations*. Retrieved from https://safety.fhwa.dot.gov/uslimits/.

5 City of Seattle. (2016). *Seattle Municipal Code*. Retrieved from https://library.municode.com/wa/seattle/codes/municipal_code.

6 City of Seattle (2022). *Seattle Geo Data: Urban Centers, Villages, Manufacturing Industrial Centers*. Retrieved from https://data-seattlecitygis.opendata.arcgis.com/datasets/urban-centers-villages-manufacturing-industrial-centers/explore?location=47.620656%2C-122.335550%2C12.00.

- **Ongoing effort:** The city's speed limit reduction work is ongoing, and it continually evaluates all arterial streets and reduces speed limits where appropriate. This is a collaborative process that involves the city and external agency partners.

Implementation

As part of the city's efforts to reduce vehicular speeds in Seattle, SDOT implemented a speed limit reduction by modified signage. SDOT did not market the speed limit reduction changes through a communications campaign, did not increase enforcement, or make any other engineering adjustments to the street design, geometry, or signal timing (any changes were made prior to the speed limit signage modifications). By removing these variables, SDOT was able to review the safety and speed impacts of two specific changes: speed limit signs with a new reduced speed and increased speed limit sign density.

Before speed limit reduction implementation efforts, locations had 30 mph signs with sign spacing ranging from 1 to 1.5 miles in each direction or they were unsigned (with a default 25 mph speed limit). After implementation, all locations included new 25 mph signs spaced at 0.25 mile intervals in each direction. A before-after study was conducted at individual corridors and urban centers/villages in 2020 to evaluate the impact of reducing speed limits on speeds and safety, as summarized in **Table 9**.[7]

[7] Seattle Department of Transportation. (2020). *Speed Limit Case Studies*. Retrieved from http:// www.seattle.gov/documents/Departments/SDOT/VisionZero/SpeedLimit_CaseStudies_Report.pdf.

Table 9. Speed limit evaluation data collection in Seattle.

Street	Study Area Type	ADT (veh/ day)	Previous Speed Limit (mph)	Previous Speed Limit Sign Spacing (mi)	Implementation
Greenwood/ Phinney Ave N	1.3 mi corridor	13,000	30	1	Replaced existing 30 mph speed limit signs with 25 mph signs and installed new 25 mph signs at .25 mile spacing
NW/N 85th St	1.9 mi corridor	19,000	25	Unsigned	Installed new 25 mph signs at .25 mile spacing
N/NE 45th St	2.2 mi corridor	22,500	25	Unsigned	Installed new 25 mph signs at .25 mile spacing
Green Lake/ Roosevelt Urban Village	Urban Village	N/A	30 and 25	Segments with 30 mph speed: 1.5- mi; segments with 25 mph speed limit: unsigned	Installed new 25 mph signs at .25 mile spacing
U-District Urban Center	Urban Village	N/A	30 and 25	Segments with 30 mph speed: 1.5- mi; segments with 25 mph speed limit: unsigned	Installed new 25 mph signs at .25 mile spacing

Source: City of Seattle, Seattle Department of Transportation Speed Limit Case Studies. Retrieved from http://www.seattle.gov/documents/Departments/SDOT/VisionZero/SpeedLimit_CaseStudies_Report.pdf.

Outcomes

For each study area included in the before-after analysis, speed limit reduction in Seattle resulted in the speed and safety outcomes shown in **Table 10**:

Table 10. Outcomes of speed limit reductions in Seattle.

Street	All Crashes	Injury Crashes	50th Percentile Speed	85th Percentile Speed	Number of Vehicles Traveling at 40 mph or Greater
Greenwood/ Phinney Ave N	-35%	-21%	-7%	-7%	-64%
NW/N 85th St	-39%	-31%	-3%	-1%	-45%
N/NE 45th St	-14%	-11%	-25%	-12%	-66%
Green Lake/ Roosevelt Urban Village	-24%	-13%	-2%	-4%	-47%
U-District Urban Center	-18%	-18%	-15%	-9%	-66%
OVERALL	**-22%**	**-18%**	**-10%**	**-7%**	**-54%**

Source: City of Seattle, Seattle Department of Transportation Speed Limit Case Studies. Retrieved from http://www.seattle.gov/documents/Departments/SDOT/VisionZero/SpeedLimit_CaseStudies_Report.pdf.

Further, the city reported that target speeds set up the framework for all new projects to design to the new lower speed limit, influencing speeds before the projects go into construction.

Additional Information

The estimated cost to install speed limit signs in Seattle is $4,000 to $5,000 per mile and includes design, materials, and labor. For further information, contact James Le, SDOT Vision Zero/Proj- ect Development Division Senior Civil Engineer, at James.Le@seattle.gov.

Case Study A.8. Auckland Transport Safe Speeds—Auckland, New Zealand

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** New Zealand is committed to eliminating fatal and serious injury crashes. New Zealand's Road to Zero National Road Safety Strategy 2020–2030 focuses on Vision Zero. Auckland Transport (AT) adopted Vision Zero in 2019 with the goal of reaching zero deaths on their road network by 2050.
- **Humans make mistakes/humans are vulnerable:** Set appropriate speed limits that are safe for all road users.
- **Responsibility is shared:** International road safety experts, along with AT staff and partners, worked together to change Auckland's safety culture. Public consultation was part of the process to change speed limits in Auckland.

Background

National Context

In 2016, the Waka Kotahi New Zealand (National) Transportation Agency published the *New Zealand Speed Management Guide*. This document set out a new framework for setting safe and appropriate speed limits. This was a significant shift in what speeds limits were considered appropriate for different roads and changed expectations around speed limit setting.

Regional Context

Auckland Transport is an Auckland Council Controlled Organization accountable for delivering an efficient, effective, and safe land transport system in Tāmaki Makaurau (Auckland), New Zealand's largest city, with a population of approximately 1.6 million people.

From 2013 to 2017, Auckland experienced a 65 percent increase in road fatalities and serious injuries. In 2017 alone, the city saw 64 deaths and 749 serious injuries, a level of road trauma last seen in Auckland 20 years prior.

International road safety experts, along with AT staff, helped to encourage an important change in thinking about road safety within AT and their partners—shifting the approach from a traditional focus of "blaming individual road users" to instead "designing a more forgiving transport system where people who make common mistakes do not end up killed or seriously injured." This helped to engrain the Safe System Approach and develop a desire for Vision Zero outcomes. It was also supported by the development of several guidelines and other documents aligned to a safe system and Vision Zero. One element of this approach is Auckland Transport's Safe Speeds program.

Process

The Waka Kotahi *New Zealand Speed Management Guide* was mainly used to determine the safe and appropriate speed limit for different roads in the AT Safe Speeds program.

The *Speed Management Guide* expects that the speed limit aligns with the safe and appropriate speed (SaAS); however, it is not always necessary to change the speed limit to the SaAS. Instead, the road could be redesigned to increase the SaAS so that it supports the existing (or higher) speed limit. This is where additional infrastructure is provided so that when a crash occurs at the current operating speed, it is unlikely to result in a death or serious injury.

Evidence-based tools like Infrastructure Risk Rating (IRR)—a road assessment methodology designed to assess road safety risk based on the road and roadside environment—and safety science were used to determine the correct part of the network to focus on. IRR was important in determining the SaAS for a road segment because, unlike traditional road safety metrics, IRR doesn't consider historical crashes. Instead, IRR is a proactive measure which is used to provide an approximation of underlying levels of risk for a road segment even when no crashes have been observed. This was especially useful for lower volume parts of the network. IRR can also be considered a basic version of the International Road Assessment Programme (iRAP) tool, requiring fewer input attributes which could be generated from the following existing national datasets:

- Road stereotype
- Alignment
- Carriageway width
- Roadside hazards
- Land use
- Intersection density
- Access density
- Traffic volume

For speed management in New Zealand, the IRR assessment was undertaken at a national level, giving councils like Auckland the evidence base to target their highest risk routes. The national IRR and SaAS assessments were then made available to all New Zealand local councils through the Safer Journeys Risk Assessment Tool website, also referred to as "MegaMaps."

By combining the *Speed Management Guide* and MegaMaps metrics with AT's knowledge of the local network, AT was able to review current speed limits and determine safe and appropriate speed limits for the roads. These where then prioritized in the first tranche (phase). The next step was the bylaw consultation process which allowed Aucklanders to submit feedback on the recommended changes.

Implementation

Following reviewing and consulting with the public, a list of possible options was provided to the AT Board which can be viewed via the following link: https://at.govt.nz/media/1981112/item-131-attachment-6-open-22-october-2019-safe-speeds-implementation-options-report.pdf.

Although small changes were made from the original scope, **Table 11** shows a high percentage of the benefits of the selected option, with a total estimated deaths and serious injury (DSI) reduction of 86.6 over a 5-year period.

Table 11. Option 3 estimated costs and benefit table.

Short List/ Option	Estimated DSI Saving in five years	Benefits Realization (%)	Estimated Cost
Rural Roads (Option 3G)	51.3	100.0%	$0.5 million
City Centre (Option 4E)	24.1	96.8%	$2.8 million plus approximately $5–$10 million supporting enhanced safety measures
Urban Roads (Option 2A)	7.2	100.0%	$0.2 million
Residential (Option 2A)	1.5	100.0%	$5.4 million
Town Centres (Option 4A)	2.5	100.0%	$8.2 million
TOTAL	**86.6**	**99.1%**	**$22–$27 million**

Source: Auckland Transport, 2019.

The Speed Limit Bylaw

In October 2019, the AT Board approved the Speed Limits Bylaw (2019). This bylaw reduced the speed limit on over 800 km (497 miles) of Auckland roads. Customer surveys, as well as a Monitoring and Evaluation Plan, were set up to monitor the effectiveness of the bylaw.

References and Additional Information

Sources/Web pages for reference:

Contact us (Auckland, NZ).

Safe Speed Programme 2019: Implementation Options Report.

Speed limit changes around Auckland Public Feedback Report.

Case Study A.9. Network-Wide Speed Limit Reduction—Mornington Peninsula, Australia

Key Successes

The speed limit reductions in Mornington Peninsula, Australia resulted in the following safety outcomes:

- An average 3 mph mean operating speed reduction after 2 years of the speed limit being reduced from 68 mph to 50 mph.
- An even greater mean speed reduction of 4 mph on these roads after 2 years for a subset of roads that carry more than an average of 1,000 vehicles per day.
- An average 2.5 mph mean operating speed reduction by reducing the speed limit from 56 mph to 50 mph.
- Number of drivers traveling below the target speed of 50 mph increased significantly for both speed changes. In both cases, over 60 percent of drivers were under the target speed of 50 mph in the after period, compared with 42 percent and 46 percent, respectively, in the before period.
- An estimated 20 percent reduction in fatal and serious injury crashes on all roads.

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** Mornington Peninsula's efforts to lower speed limits has a goal of eliminating fatal and serious injury crashes.
- **Humans make mistakes/humans are vulnerable:** Reduction of speed limit to reduce crash impact forces.

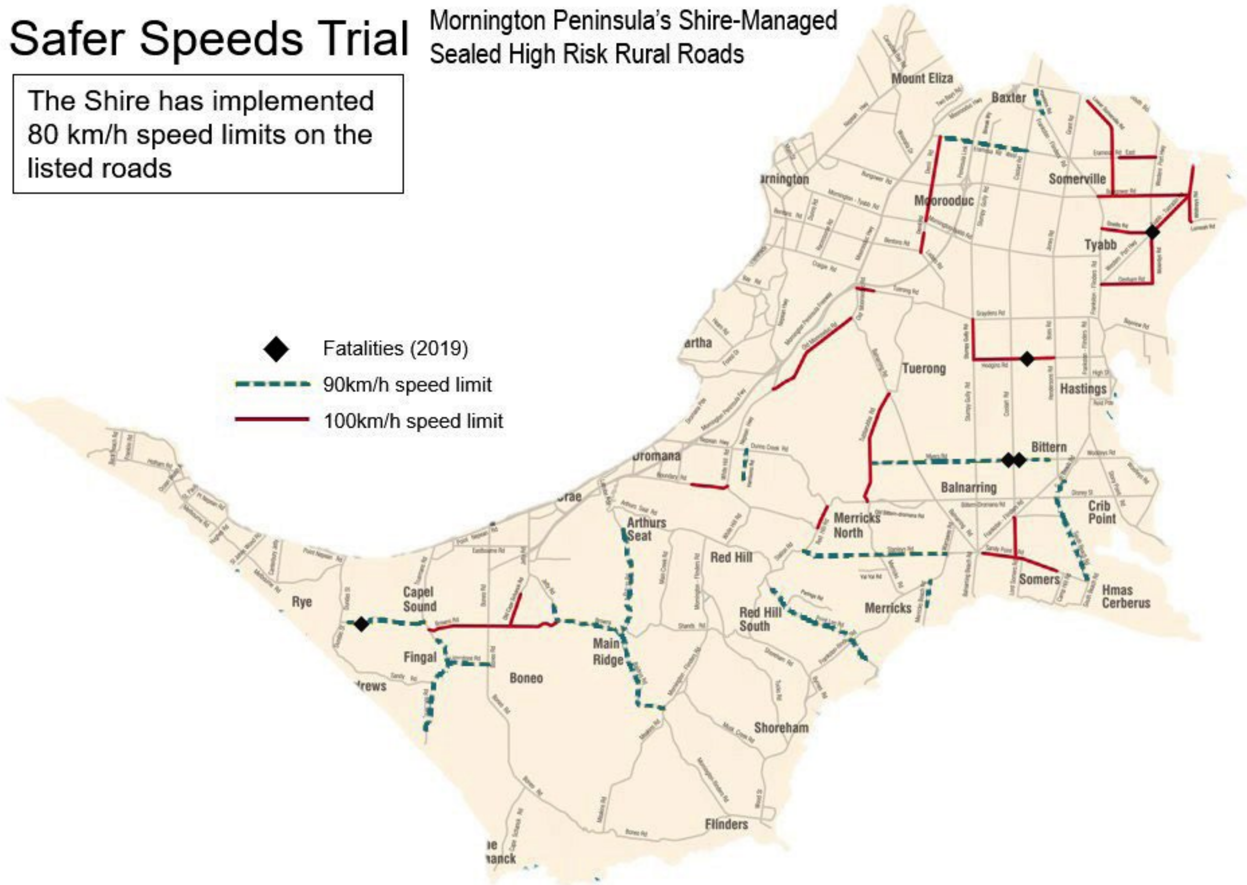
Background

Mornington Peninsula Shire is located southeast of Melbourne, Victoria, Australia and has an estimated population of 168,000. Mornington Peninsula Shire Council (MPSC) has demonstrated strong leadership in adopting and applying the Safe System approach to improve road safety in the Mornington Peninsula. Mornington Peninsula offers a unique environment in which to undertake and evaluate this speed trial. Visitors to the region, who make a significant contribution to the economy, often don't know their destination, stopping at places of interest on winding roads. These roads are unlikely to receive infrastructure treatments in the foreseeable future, and so the introduction of safer speed limits is the most suitable treatment to reduce risks on these roads for both visitors and the local community.

In 2019, Mornington Peninsula experienced significant road trauma, observing the most deaths of any local government area in Victoria. From January 2019 to November 2019, 100 people were seriously injured and 14 were killed on MPSC roads.

Implementation

To address the concerns regarding road deaths and serious injuries and to reduce safety risk in the long term in Mornington Peninsula, MPSC acted quickly in applying a network wide speed limit reduction trial. Speed limits were reduced from 56 mph or 62 mph to a new speed limit of 50 mph on 33 high-speed local roads (**Figure 15**) beginning in early 2020.



Source: Mornington Peninsula Shire.

Figure 15. Mornington Peninsula Safer Speeds Trial.

Outcomes

Program evaluations are an important part of the Victoria Department of Transport (Victoria DOT) Safer Roads program because they provide an understanding of the effectiveness of infrastructure improvements. This informs decisions regarding future treatments. Additionally, it allows for analysis and feedback on treatments that preformed inadequately. It is important that the results of evaluations are statistically robust, so that investment decisions are based on creditable information.

The Victoria DOT's "Safer Speeds on High Speed Local Government Area (LGA) Roads" evaluation framework was applied to evaluate the effectiveness of the two MPSC speed limit trials:

- Trial 1 covered speed limit reductions from 62 mph to 50 mph on 20 routes. This is shown as the red lines in **Figure 15**.

- Trial 2 covered speed limit reductions from 56 mph to 50 mph on 15 routes. This is shown as the yellow lines in **Figure 15**.

For the speed limit reduction trial, before data were collected in December 2019. Three periods of after speed data have also been collected for the evaluation, including:

- May 2020 (After 1 Period)
- November 2020 (After 2 Period); and
- November/December 2021 (After 3 Period).

Following data collection, the objective of this evaluation was to assess the following observed and expected outcomes from the trial:

- Reduction in free flow mean speeds associated with a:
  - Speed limit change from 62 mph to 50 mph (Trial 1)
  - Speed limit change from 56 mph to 50 mph (Trial 2)
- Changes in speed limit compliance associated with the speed limit changes
- Changes in the proportion of motorists traveling below 50 mph (target of "below 50 mph" proportion) and below 62 mph (target "upper bound" proportion)
- Estimated fatal and serious injury (FSI) crash reductions expected from the speed limit change

The evaluation found:

- There was very strong evidence that an average 3 mph mean operating speed reduction is achieved after 2 years of the speed limit being reduced from 62 mph to 50 mph, a 12 mph drop.
- An even greater mean speed reduction of 4 mph was observed after 2 years for a subset of roads that carry more than an average of 1,000 vehicles per day.
- Across all after periods, a higher speed reduction was observed on a subset of roads that have higher operating speeds in the before case, and therefore a higher risk of FSI crashes.
- The 56 mph to 50 mph speed limit reductions showed some evidence of a 2.5 mph reduction in mean speeds.
- The number of drivers traveling below the target speed of 50 mph increased significantly for both the 62 mph to 50 mph and 56 mph to 50 mph speed changes. In both cases, more than 60 percent of drivers were under the target speed of 50 mph in the after period compared with 46 percent and 42 percent, respectively, in the before period. This is an important outcome from a Safe System perspective, as more drivers below these target speeds will significantly reduce the risk of FSI crashes.
- The trial also estimated an average reduction in FSI crashes of approximately 20 percent for the 62 mph to 56 mph roads. Some routes showed reductions as high as 34 percent.
- For the 56 mph to 50 mph routes, the reductions are likely to be less, with an average FSI reduction of 12 percent across the treated routes.

Case Study A.10. Speed Limit Reduction on Urban Roads—Republic of Korea

Key Successes

The speed limit reductions on urban roads in Korea resulted in the following safety outcomes:

- A 1.1 percent reduction in total crashes
- A 19.3 percent reduction in fatalities
- A 9.2 percent reduction in injuries
- A 4.8 percent equivalent property damage only (EPDO) reduction
- An 18.4 percent reduction in fatalities per 100 crashes

The Safe System Approach Highlights

- **Death/serious injury is unacceptable:** Reducing road fatalities is the main goal of speed limit reductions in Korea
- **Humans make mistakes/humans are vulnerable:** Speed limit reductions focused on pedestrian safety

Background

Information in this case study is summarized from a joint research project conducted by the Korea Transport Institute (KOTI) and the World Bank (Mitra, Job, Han, and Eom 2021).

In April 2016, the National Police Agency in Korea established the Transportation Infrastructure Construction Basic Plan. For the first time, the Safe Speed 5030 policy was adopted to improve urban pedestrian safety. Following this, the 5030 Council was formed; this included the Ministry of Land, Infrastructure, and Transport as well as several other relevant agencies. In the same year, the 8th National Road Safety Basic Plan was presented.

Implementation

Three years after presentation of the 8th National Road Safety Basic Plan, the Approved Code of Practice of the Road Traffic Act was amended. This set the maximum urban speed limit at 31 mph. However, the country's National Policy Agency has gone further, changing the speed limit of many urban roads to 19 mph.

To assess the safety benefits of lower speed limits on urban roads and to inform future policy development on speed limits in urban areas, the Korea Transport Institute (KOTI) and the World Bank conducted a joint research project. Specifically, this study analyzed how changes in the speed limit affected safety performance and operational performance. **Table 12** shows the extent of the speed limit reductions that were implemented across cities in Korea.

Table 12. Korea case study – current status of lowering speeds across Korea.

Local government	Number of reduction sections	Official data release date	Other
Seoul City	2,534	08/31/2016	Speed limit reductions tend to be 19 mph reduction sections due to designation as protection zones
Daegu City	865	09/2017	-
Daejeon City	168	08/22/2016	-
Chungcheongbuk-do Province	253	08/30/2011	-
Jeollanam-do Province	754	09/19/2016	-
Gyeongsangbuk-do Province	313	08/31/2016	-
Jeju-do Province	162	04/2019	-

- = No data.

Source: Mitra, S., Job, S., Han, S., Eom, K. (2021). *Do Speed Limits Reductions Help Road Safety? Lessons from the Republic of Korea's Recent Move to Lower Speed Limit on Urban Road*. Washington, DC: World Bank. http://hdl.handle.net/10986/36109.

Outcomes

After speed limit reduction in Korea, the joint research project conducted by KOTI and the World Bank evaluated the following:

1 The effectiveness of the reduced speed limits in terms of crash reduction through a before- after study.

2 If speed limit change had different effects across different crash types, user types, and crash severities.

3 The impact of speed limit change on transit speed through a before-after assessment.

To evaluate the effectiveness of speed limit reductions, the study team used an observational before-after study with a control group. The team obtained counts of crashes before and after in both the treatment site and comparison groups. Several different comparison analyses were con- ducted to check the impact of speed limit reductions. The following crash types were evaluated in the analysis:

1 Total crashes

2 Vehicle-to-vehicle crashes

3 Pedestrian crashes

Table 13 shows the overall results of the analysis. The results showed good alignment in moving towards the Safe System principles of accepting that crashes are inevitable, but they shouldn't result in death or serious injury. This is shown by the relatively insignificant decrease in total crashes but a significant decrease in the number of people being injured or killed. Fatalities on roads where speed limits were changed were reduced by 19.3 percent compared to a 6.8 percent decrease in the control group.

Table 13. Korea case study – results of speed limit changes.

	Crashes	Fatalities	Injuries	Equivalent Property Damage Only Crashes (EPDO)	Fatalities per 100 Crashes
Before change in speed limit	8,891	114	3,142	19,869	1.28
After change in speed limit	8,794	92	2,852	18,906	1.05
Percent reduction	1.1%	19.3%	9.2%	4.8%	18.4%
Sections with unchanged speed limit, percent reduction	-3.0%	6.8%	11.8%	3.0%	9.6%

Note: A negative (-) sign before the percent change indicates an increase.

Source: Mitra, S., Job, S., Han, S., Eom, K. (2021). Do Speed Limits Reductions Help Road Safety? Lessons from the Republic of Korea's Recent Move to Lower Speed Limit on Urban Road. Washington, DC: World Bank. http://hdl.handle.net/10986/36109.

REFERENCES

AASHTO. (2010). *Highway Safety Manual.* Washington, D.C.: America Association of State Highway and Transportation Officials.

AASHTO. (2011). *Roadside Design Guide, 4th Edition.* Washington, D.C.: American Association of State Highway and Transportation Officials.

AASHTO. (2018). *A Policy on Geometric Design of Highways and Streets.* Washington, D.C.: American Association of State Highway and Transportation Officials.

Archer, J., Fotheringham, N., Symmons, M., Corben, B. (2008). *The Impact of Lowered Speed Limits in Urban/Metropolitan Areas.* MUARC Report No. 276. Victoria: Monash University Accident Research Center.

Caltrans. (2021). Complete Streets. Sacramento, CA: California Department of Transportation.

Cameron, M.H., Elvik, R. (2008). Nilsson's power model connecting speed and road trauma: does it apply on urban roads? Presented to the 2008 Australasian Road Safety Research, Policing and Education Conference. Adelaide, South Australia.

Carter, D., Srinivasan, R., Gross, F., and Council, F. (2012). *Recommended Protocols for Developing Crash Modification Functions.* Washington, D.C.: AASHTO.

Caviedes, A., and Figlioizzi, M. (2018). Modeling the impact of traffic conditions and bicycle facilities on cyclists' on-road stress levels. *Transportation Research Part F: Traffic Psychology and Behaviour,* 58, 488-499.

City of Baltimore. (2021). *Baltimore Complete Streets.* Baltimore, MD: City of Baltimore.

City of Fremont. (2016). *Fremont Vision Zero 2020: A Focused and Collaborative Effort to Improve Street Safety and Reduce Traffic Fatalities to Zero.* Fremont, CA: City of Fremont.

City of New York. (2020). *New York City Automated Speed Enforcement Program: 2014-2020 Report.* New York City, NY: City of New York.

City of Seattle. (2020). Seattle Department of Transportation Speed Limit Case Studies. Retrieved from CaseStudies_Report.pdf.

City of Seattle. (2015). *Vision Zero: Seattle's Plan to End Traffic Deaths and Serious Injuries by 2030.* Seattle, WA: City of Seattle.

Combs, T. S., and Pardo, C. F. (2021). Shifting streets COVID-19 mobility data: Findings from a global dataset and a research agenda for transport planning and policy. *Transportation Research Interdisciplinary Perspectives, 9*, 100322. doi:https://doi.org/10.1016/j.trip.2021.100322.

Corben, B. (2020). *Integrating Safe System with Movement and Place for Vulnerable Road Users.* Sydney, New South Wales: Austroads.

Decina, L. E., Thomas, L. J., Srinivasan, R., and Staplin, L. (2007). *Automated enforcement: A compendium of worldwide evaluations of results.* Washington, D.C.: National Highway Traffic Safety Administration.

Doctor, M., Ngo, C., Ocel, N., Scurry, K., and Shaw, J. (2020). Safe System – An Approach Toward Zero Traffic Deaths. FHWA's *Safety Compass Newsletter, 14*(3), 4-6.

Doecke, S. D., Kloeden, C. N., Dutschke, J. K., and Baldock, M. R. (2018). Safe speed limits for a safe system: The relationship between speed limit and fatal crash rate for different crash types. *Traffic Injury Prevention, 19*(4), 404-408. doi: 10.1080/15389588.2017.1422601.

Donnell, E., Kersavage, K., and Fontana Tierney, L. (2018). *Self-Enforcing Roadways: A Guidance Report.* Washington, D.C.: Federal Highway Administration.

Dumbaugh, E., Signor, K., Kumfer, W., LaJeunesse, S., Carter, D., and Merlin, L. (2019). *Safe Systems: Guiding Principles and International Applications.* Chapel Hill, NC: Collaborative Sciences Center for Road Safety.

Elvik, R. (2005). Speed and Road Safety: Synthesis of Evidence from Evaluation Studies. *Transportation Research Record: Journal of the Transportation Research Board, 1908*(1), 59-69. doi:https://doi.org/10.3141/1908-08.

Engel, U., Thomsen, L.K. (1988). *Speeds, speed limits and accidents. The road safety trend inbuilt up areas after the introduction of the 50 km/h limit*. Technical Report 3/1988, Danish Council of Road Safety Research, Gentofte, Denmark.

Etika, A. (2018). *Developing safe system road safety indicators for the UK.* London: Parliamentary Advisory Council for Transport Safety.

European Commission. (2018). *Speed and Speed Management.* European Commission, Directorate General for Transport.

European Conference of Ministers of Transport. (2000). *Safety in Road Traffic for Vulnerable Users.* Paris, France: OECD.

FDOT. (2016). *Complete Streets Handbook.* Tallahassee, FL: Florida Department of Transportation.

FDOT. (2018). *West Busch Boulevard Corridor Alternatives and Strategies Report.* Tallahassee, FL: Florida Department of Transportation.

FDOT. (2022). *FDOT Design Manual: Development and Processes.* Tallahassee, FL: Florida Department of Transportation.

FHWA. (2009). *Manual on Uniform Traffic Control Devices (MUTCD).* Washington, D.C.: Federal Highway Administration.

FHWA. (2017a). *Speed Limit Basics.* Washington, D.C.: Federal Highway Administration.

FHWA. (2017b). "Speed Management." (website). https://highways.dot.gov/safety/speed-management.

FHWA. (2017c). *Speed Management Countermeasures: More than Just Speed Humps.* Washington, D.C.: Federal Highway Administration.

FHWA. (2019). *Improving Speed Management Using a Systemic Safety Approach.* Washington, D.C.: Federal Highway Administration.

FHWA. (2020a). *The Safe System Approach.* Washington, D.C.: Federal Highway Administration.

FHWA. (2020b). *USLIMITS2: ATool to Aid Practitioners in Determining Appropriate Speed Limit Recommendations*. Retrieved from https://safety.fhwa.dot.gov/uslimits/.

FHWA. (2020c). *Equity in Vision Zero - Oregon Metro.* FHWA-SA-20-011. Washington, D.C.: Federal Highway Administration.

FHWA. (2021). *Appropriate Speed Limits for All Road Users*. Retrieved from Proven Safety Countermeasures: https://safety.fhwa.dot.gov/provencountermeasures/appropriate- speed-limits.cfm.

FHWA. (2022a). *Moving to a Complete Streets Design Model: A Report to Congress on Opportunities and Challenges.* Washington, D.C.: Federal Highway Administration.

FHWA. (2022b). *Complete Streets in FHWA.* Retrieved from U.S. Department of Transportation Federal Highway Administration: https://highways.dot.gov/complete-streets.

FHWA. (2023). *Safe System Approach in the Urban Core.* FHWA-SA-23-001. Washington, DC: Federal Highway Administration.

FHWA Office of Safety. (2021). *Proven Safety Countermeasures: Speed Safety Cameras.* Washington, D.C.: Federal Highway Administration.

FHWA Office of Safety. (2022). *Updated HSIP Guidance under the Bipartisan Infrastructure Law.* Washington, D.C.: Federal Highway Administration.

FHWA; ITE. (2017). *Traffic Calming ePrimer*. Retrieved from https://safety.fhwa. dot.gov/speedmgt/traffic_calm.cfm.

Fildes, B., Langford, J., Andrea, D., and Scully, J. (2005). *Balance between Harm Reduction and Mobility in Setting Speed Limits: A Feasibility Study.* Sydney, NSW: Austroads Inc.

Finch, D.J., Kompfner, P., Lockwood, C.R., and Maycocok, G. (1994). *Speed, speed limits and accidents.* Berkshire, UK: Transport Research Laboratory, Project Report 58.

Finkel, E., McCormick, C., Mitman, M., Abel, S., and Clark, J. (2020). *Integrating the Safe System Approach with the Highway Safety Improvement Program: An Informational Report.* Washington, D.C.: Federal Highway Administration.

Finley, K., Otto, J., Ward, N., and Jamie Arpin, J. (2019). *Proactive Safety Culture - Empowering Behaviors to Reach Our Shared Vision of Zero Deaths and Serious Injuries.* Bozeman, MT: Center for Health and Safety Culture - Western Transportation Institute - Montana State University.

Fisher, D. L., Breck, A., Gillham, O., and Flynn, D. (2021). *Effectiveness of dynamic speed feedback signs, Volume I: Literature review and metal analysis* (Report No. DOT HS 813 170-A). National Highway Traffic Safety Administration.

Fitzpatrick, K., Das, S., Pratt, M., Dixon, K., and Gates, T. (2021). *Posted Speed Limit Setting Procedure and Tool - User Guide.* Washington, D.C.: Transportation Research Board.

Frith, W. J., Toomath, J. B. (1982). The New Zealand open road speed limit. *Accident Analysis & Prevention*, 14(3): 209–218. https://doi.org/10.1016/0001-4575(82)90032-X.

Flynn, J., and Yassin, M. (2012). *Community-Oriented BRT: Urban Design, Amenities, and Placemaking.* Washington, D.C.: Federal Transit Administration.

Forbes, G. J., Gardner, T., McGee, H., and Srinivasan, R. (2012). *Methods and Practices for Setting Speed Limits: An Informational Report.* Washington, D.C.: Federal Highway Administration.

Foster, N., Gross, N., Braughton, M., Ray, B., Lacy, B., Chandler, B., and Monsere, C. (2020). *Implementation of NCHRP Research Report 893: The Oregon DOT Statewide Pedestrian and Bicycle Plan.* Washington, D.C.: Transportation Research Board.

Gaca, S., and Pazdan, S. (2017). Speed management as a measure to improve safety on Polish regional roads. *Archives of Transport, 43*(3), 29-42. doi:10.5604/01.3001.0010.4225

Glandorf, J. (2020). *Slow Streets Movement Looks to Reimagine Urban Spaces Amid Coronavirus Pandemic*. Retrieved from Environmental and Energy Study Institute: https://www.eesi.org/articles/view/slow-streets-movement-looks-to-reimagine-urban-spaces-amid-coronavirus-pandemic#:~:text=Slow%20Streets%20programs%20place%20barriers,space%20for%20pedestrians%20and%20cyclists.

Gonzalez, K., and Lungu, C. (2021, June 15). *Building "Streets for Life:" The many benefits of lower speed limits*. Retrieved from World Bank Blogs: https://blogs.worldbank.org/transport/building-streets-life-many-benefits-lower-speed-limits#:~:text=Healthier%20cities%2C%20a%20healthier%20planet,climate%20impact%20of%20urban%20transport.

Grant, M., and Bowen, B. (2020). *Opportunities for Research on Transportation and Equity.* Washington, D.C.: Transportation Research Board.

Grembek, O., Chen, K., Taylor, B. D., Hong Hwang, Y., Fitch, D., Anthoine, S.,. Grover, S. (2020). *Research Synthesis for the California Traffic Fatalities Task Force.* Berkeley, CA: The University of California Institute of Transportation Studies.

Green, F., Gunatillake, T., Styles, T. (2003). *Evaluation of the 50km/h residentialspeed limit in the ACT*. Report prepared for the Department of Urban Services by ARRB Transport Research, Report RC 1847.

Gross, F., Harmon, T., Bahar, G., and Peach, K. (2016). *Reliability of Safety Management Methods: Systemic Safety Programs.* Washington, D.C.: Federal Highway Administration Office of Safety.

Hallmark, S. L., Hawkins, N., and Knickerbocker, S. (2015). Use of DSFS as a Speed Transition Zone Countermeasure in Small, Rural Communities. *IEEE 18th International Conference on Intelligent Transportation Systems* (pp. 1448-1454). Gran Canaria, Spain: IEEE. doi:10.1109/ITSC.2015.237.

Harmon, K. J., Hancock, K., Rodgman, E., Sandt, L., and Thomas, L. (2021). *Using Integrated Data to Examine Characteristics Related to Pedestrian Injuries.* Chapel Hill, NC: Collaborative Sciences Center for Road Safety.

Hawkins, N., and Hallmark, S. (2020). *Noteworthy Speed Management Practices.* Washington, D.C.: Federal Highway Administration Office of Safety.

Hillier, P., Makwasha, T., and Turner, B. (2016). *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice.* Sydney: Austroads.

Hoareau, E. and Newstead, S. (2004). A*n evaluation of the default 50km/h speed limit in Western Australia*. Report No. 230. Victoria: Monash University Accident Research Center.

Hoareau, E., Newstead, S., and Cameron, M. (2006). *An evaluation of the default 50 km/h speed limit in Victoria*. Report No. 261, Monash University Accident Research Centre, November 2006.

Hu, W., and Cicchino, J. B. (2020). Lowering the speed limit from 30 mph to 25 mph in Boston: effects on vehicle speeds. *Injury Prevention,* 26: 99–102. 10.1136/injuryprev-2018-043025

IIHS. (2020, June 16). *New study suggests today's SUVs are more lethal to pedestrians than cars*. Retrieved from https://www.iihs.org/news/detail/new-study-suggests-todays-suvs-are-more- lethal-to-pedestrians-than-cars.

IIHS. (2021, May). *Speed*. Retrieved from https://www.iihs.org/topics/speed.

Institute of Transportation Engineers. (2022). A Guide to Speed Reduction Techniques: Planning and Design of Speed Humps, Speed Tables, and Other Related Measures - A Proposed Recommended Practice.

ITE. (2016). *Traffic Engineering Handbook, 7th Edition.* Washington, D.C.: Institute of Transportation Engineers.

ITE. (2021). *Safe System*. Retrieved from Technical Resources: https://www.ite.org/technical-resources/topics/safe-systems/.

ITF. (2016). *Zero Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System.* Paris: OECD Publishing. http://dx.doi.org/10/1787/9789282108055-en.

Ivan, J. N., Garrick, N. W., and Hanson, G. (2009). *Designing Roads that Guide Drivers to Choose Safer Speeds.* Rocky Hill, CT: Connecticut Department of Transportation.

Johns Hopkins University, ITE, and the FIA Foundation. (2021). *Recommendations of the Safe System Consortium.* Baltimore, MD: Johns Hopkins University.

Jurewicz, C. (2009). Impacts of safer speed limits on road network operations. *Australasian Road Safety Research, Policing and Education Conference* (pp. 678-681). Sydney, New South Wales: ARRB Group Ltd.

Jurewicz, C., and Hall, K. (2009). Speed limit setting principles in the Safe System context. *Australasian Road Safety Research, Policing and Education Conference.* Sydney, New South Wales: ARRB Group Ltd, VicRoads.

Jurewicz, C., and Turner, B. (2010). *Infrastructure/Speed Limit Relationship in Relation to Road Safety Outcomes.* Sydney, New South Wales: Austroads.

Jurewicz, C., Sobhani, A., Woolley, J., Dutschke, J., and Corben, B. (2016). Exploration of vehicle impact speed - injury severity relationships for application in safer road design. *Transportation Research Procedia, 14*, 4247-4256. doi: 10.1016/j.trpro.2016.05.396.

Khan, N. A., and Habib, M. A. (2022). Exploring the impacts of built environment on pedestrian injury severity involving distracted driving. *Journal of Safety Research, 80*, 97-108. https://www.sciencedirect.com/science/article/pii/S0022437521001390.

Khattak, A., Ahmad, N., Wali, B., and Dumbaugh, E. (2019). *Developing a Taxonomy of Human Errors and Violations that Lead to Crashes.* Chapel Hill, NC: Collaborative Sciences Center for Road Safety.

Kloeden, C., Woolley, J., McLean, J. (2007*). A follow-up evaluation of the 50 km/h defaulturban speed limit in South Australia*. Proceedings, Australasian Road Safety Research, Policing Education Conference, Melbourne.

Knapp, K., Chandler, B., Atkinson, J., Welch, T., Rigdon, H., Retting, R., Porter, R. (2014). *Road Diet Informational Guide.* Washington, D.C.: Federal Highway Administration.

Kumfer, W., LaJeunesse, S., Sandt, L., and Thomas, L. (2019). Speed, Kinetic Energy, and the Safe Systems Approach to Safer Roadways. *ITE Journal*, 32-36.

LaJeunesse, S., Naumann, R. B., Sandt, L., Spade, C., and Evenson, K. R. (2020). *Guide to Developing a Vision Zero Plan.* Chapel Hill, NC: Collaborative Sciences Center for Road Safety.

Li, H., Zhu, M., Graham, D. J., and Zhang, Y. (2020). Are multiple speed cameras more effective than a single one? Causal analysis of the safety impacts of multiple speed cameras. *Accident Analysis & Prevention, 130.* https://doi.org/10.1016/j.aap.2020.105488.

Mitra, S., Job, S., Han, S., Eom, K. (2021). *Do Speed Limits Reductions Help Road Safety? Lessons from the Republic of Korea's Recent Move to Lower Speed Limit on Urban Road*. Washington, DC: World Bank. http://hdl.handle.net/10986/36109.

Monfort, S. S., and Mueller, B. C. (2020). *Pedestrian injuries from cars and SUVs: updated crash outcomes from the Vulnerable Road User Injury Prevention Alliance (VIPA).* Ruckersville, VA: Insurance Institute for Highway Safety.

Montgomery County Department of Police. (2022). *Speed Camera Placement*. Retrieved from https://www.montgomerycountymd.gov/pol/howdoI/request-speed-camera.html.

Montgomery County Planning Department. (2022). *Predictive Safety Analysis Final Report.* Wheaton, MD: Montgomery County Planning Department.

NACTO. (2020). *City Limits: Setting Safe Speed Limits on Urban Streets.* New York, NY: National Association of City Transportation Officials.

National Highway Traffic Safety Administration (NHTSA). (2022b). *Traffic Safety Facts: Early Estimates of Motor Vehicle Traffic Fatalities and Fatality Rate by Sub-Categories in 2021*. DOT HS 813 298. Washington, DC: NHTSA. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813298.

NHTSA. (2022). "Traffic Safety Facts: Speeding." DOT HS 813 320. Washington, DC: NHTSA. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813320.

National Safety Council. (2022b). *Speeding*. Retrieved from Motor Vehicle Safety Issues: https:// injuryfacts.nsc.org/motor-vehicle/motor-vehicle-safety-issues/speeding/.

Nilsson, G. (1990). *Reduction of the 110 Km/H Speed Limit to 90 Km/H During Summer 1989. Effects On Personal Injury Accidents, Injured and Speeds*. Report. No. VTI–358. Linkoeping Sweden: National Swedish Road & Traffic Research Institute.

Nordback, K., Kumfer, W., LaJeunesse, S., Thomas, L., Heuser, K., and Griswold, J. (2019). *National Pedestrian and Bicycle Safety Data Clearinghouse Phase I: Inventory and Framework.* Chapel Hill, NC: Collaborative Sciences Center for Road Safety.

NTSB. (2017). *Safety Study: Reducing Speeding-Related Crashes Involving Passenger Vehicles.* Washington, D.C.: National Transportation Safety Board.

Patterson, T.L., Frith, W.J. (2001). *Speed Variation, Absolute Speed and Their Contribution to Safety, with Special Reference to the Work of Solomon*. Institution of Professional Engineers New Zealand (IPENZ) Transportation Group Conference. Technical Papers 2001.

PBOT. (2016). *Vision Zero Action Plan: Saving Lives with Safe Streets.*

PBOT. (2016). *City of Portland's Proposed Speed Zone Review Methodology.* Portland, OR: Portland Bureau of Transportation.

Peden, Scurfield, Sleet, Mohan, Hyder, Jarawan, and Mathers. (2004). *World report on road traffic injury prevention.* Geneva: World Health Organization.

Peltola, H. (1991). Seasonally Changing Speed Limit*.* Presented at PTRC European Transport, Highways and Planning 19th Summer Annual Meeting, University of Sussex, *Proceedings of Seminar K*, Volume P350.

Porter, R., Dunn, M., Soika, J., Huang, I., Coley, D., Gross, A., Heiny, S. (2021). *A Safe System-Based Framework and Analytical methodology for Assessing Intersections.* FHWA-SA-21-008. Washington, D.C.: Federal Highway Administration Office of Safety.

Preston, H., Storm, R., Bennett, J. D., and Wemple, B. (2013). *Systemic Safety Project Selection Tool.* Washington, D.C.: Federal Highway Administration Office of Safety.

Ryus, P. et al. (2022). *NCHRP Report 992: Guide to Pedestrian Analysis.* Washington, D.C.: The National Academies Press. https://doi.org/10.17226/26518.

Sanders, R. L., Judelman, B., and Schooley, S. (2019). *Pedestrian safety relative to traffic-speed management: A synthesis of highway practice.* Washington, D.C.: Transportation Research Board.

Sandt, L., Brookshire, K., Heiny, S., Blank, K., and Harmon, K. (2020). *Toward a Shared Understanding of Pedestrian Safety: An Exploration of Context, Patterns, and Impacts.* Chapel Hill, NC: Pedestrian and Bicycle Information Center.

Scharping, F.K. (1994). *Experience Report. 30 Km/H Speed Limited Zones in Hamburg. Speed Reduction Measures On Major Inner City Roads*. Transportation Research Institute. Haifa, Israel: Technion–Israel Institute.

Sharpin, A. B., Adriazola-Steil, C., Luke, N., Job, S., Obelheiro, M., Bhatt, A., Lleras, N. (2021). *Low-Speed Zone Guide.* World Resources Institute.

Smart Growth America. (2022). Policy Inventory. Retrieved from Complete Streets policies: https://smartgrowthamerica.org/program/national-complete-streets-coalition/policy-atlas/.

Soames, J., and Brodie, C. (2022). Understanding the Role of Speeding and Speed in Serious Crash Trauma: A Case Study of New Zealand. *Journal of Road Safety, 33*(1), 5-25. doi:https:// doi.org/10.33492/JRS-D-21-00069.

Sliogeris, J., (1992). *110 Kilometer Per Hour Speed Limit-Evaluation of Road Safety Effect*. Report. No. GR 92–8. VicRoads. Australia.

Stewart, T. (2022). *Overview of Motor Vehicle Crashes in 2020.* Washington, D.C.: National Highway Traffic Safety Administration.

Stewart, T. 2023. *Overview of Motor Vehicle Traffic Crashes in 2021*. DOT HS 813 435. Washington, DC: NHTSA.

Stuster, J., Coffman, Z. (1998). *Synthesis of Safety Research Related to Speed and Speed Management*. FHWA-RD-98-154. Washington, D.C.: Federal Highway Administration and National Highway Traffic Safety Administration.

Sutton, S., and Tilahun, N. (2022). *Red-Light and Speed Cameras: Analyzing the Equity and Efficacy of Chicago's Automated Camera Enforcement Program.* Chicago, IL: Department of Urban Policy and Planning, University of Chicago Illinois.

Swedish Road Administration. (2006). *Safe traffic: Vision Zero on the move.* Borlänge, Sweden: Swedish Road Administration.

Tefft, B. (2013). Impact Speed and a Pedestrian's Risk of Severe Injury or Death. *Accident Analysis & Prevention, 50*, 871-878.

Theeuwes, J. (2021). Self-explaining roads: What does visual cognition tell us about designing safer roads? *Cognitive Research: Principles and Implications*, 6(15). Online. https://cognitiveresearchjournal.springeropen.com/articles/10.1186/s41235-021-00281-6.

Thomas, L., Sandt, L., Zegeer, C., Kumfer, W., Lang, K., Lan, B., Schneider, R. J. (2018). *Systemic Pedestrian Safety Analysis.* Washington, D.C.: Transportation Research Board.

Tingvall, C., and Haworth, N. (1999). Vision Zero - An Ethical Approach to Safety and Mobility. *6th ITE International Conference* (p. 7.). Victoria Police.

Turner, S. L., Khoo, J., Bosher, S., and Trumper, H. (2014). *Safer speeds: public acceptance and compliance.* Wellington, NZ: NZ Transport Agency.

U.S. Department of Transportation (2015). *Complete Streets*. Retrieved from: U.S. Department of Transportation Mission: https://www.transportation.gov/mission/health/complete-streets.

U.S. Department of Transportation. (2022a). *National Roadway Safety Strategy.* Washington, D.C.: United States Department of Transportation.

U.S. Department of Transportation. (2022b). *Safe Streets and Roads for All (SS4A) Grant Program.* Retrieved from Safe Streets and Roads for All Grants: https://www. transportation.gov/grants/SS4A#:~:text=The%20Bipartisan%20Infrastructure%20Law%20 (BIL,roadway%20deaths%20and%20serious%20injuries.

Vision Zero Network. (n.d.). *9 Components of a Strong Vision Zero Commitment.* New York City, NY: Vision Zero Network.

Vision Zero Network. (n.d.). *Taming Speed for Safety: A Defining Approach and Leadership from Portland, Oregon.* New York City, NY: Vision Zero Network.

Waka Kotahi. (2022). *Speed and infrastructure*. Retrieved from Waka Kotahi NZTA: https:// www.nzta.govt.nz/safety/partners/speed-and-infrastructure/.

Walsh, D., Smith, M. (1999). Effective speed management: The next step forward: Saving lives by decreasing speeds in local streets. Paper presented to the *1999 Research, Policing, Education Road Safety Conference*, pp.685-694.

Wang, J., Huang, H., and Zeng, Q. (2017). The effect of zonal factors in estimating crash risks by transportation modes: Motor vehicle, bicycle, and pedestrian. *Accident Analysis & Prevention, 98*, 223-231. doi:https://doi.org/10.1016/j.aap.2016.10.018.

Washington Injury Minimization and Speed Management Policy and Guidelines Workgroup. (2020). *Washington State Injury Minimization and Speed Management Policy Elements and Implementation Recommendations.* Olympia, WA: Washington Injury Minimization and Speed Management Policy and Guidelines Workgroup.

Weijermars, W., and Wegman, F. (2011). Ten Years of Sustainable Safety in the Netherlands: An Assessment. *Transportation Research Record: Journal of the Transportation Research Board, 2213*(1), 1-8. doi:https://doi.org/10.3141/2213-01.

WHO. (2004). *World report on road traffic injury.* Geneva, Switzerland: World Health Organization.

WHO. (2008). *Speed management: a road safety manual for decision-makers and practitioners.* Geneva: World Health Organization.

Woolley, J., (2005). Recent Advantages of Lower Speed Limits in Australia. *Journal of Eastern Asia Society for Transportation Studies*, Vol.6, pp. 3562–3573.

Zia, H., Harris, D., and Smith, D. (2019). *Infrastructure Risk Rating Manual for Australian Roads.* Sydney, New South Wales: Austroads.

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