Supporting Systems and Technologies

Behavior, crash type, and road users are only part of the story of traffic safety. Several supporting systems and technologies contribute to roadway safety in our state:

- Traffic Data Systems
- Emergency Medical Services (EMS) and Trauma Care System
- Evaluation, Analysis, and Diagnosis
- Cooperative Automated Transportation—Includes Automated Vehicles
- Safe Systems Approach

Some of these elements are having an immediate effect on our safety outcomes, such as EMS and Trauma Care System, and Evaluation, Analysis, and Diagnosis. Others are having a smaller immediate effect currently, but have the potential to have major decreases in fatalities and serious injuries over time, such as Safe Systems and Cooperative Automated Transportation. These systems and technologies are relatively new, but will mature over time to be more widespread. As they enter full-scale deployment, they have the potential to have increasingly powerful effects on traffic safety.

Traffic Safety Data Systems

Washington State's Traffic Records Systems (TRS) provides the primary source of knowledge about Washington's transportation environment. The TRS is a collection of information about crashes, vehicles, drivers, citations, legal outcomes, and injuries in Washington. Collectively, these systems help partners determine how to reduce injuries and fatalities on our roadways.

TRS provides Target Zero the quality data needed to:

- Diagnose the contributing factors to crashes.
- Analyze the roadway system to identify locations or corridors with higher numbers of fatal and serious injury crashes compared to similar locations on the system.
- Assess the effectiveness of implemented countermeasures.
- Identify innovative and targeted strategies that will have the greatest effect on achieving the goal of zero fatalities and serious injuries.

In order to help us save lives and prevent injuries, TRS must be able to provide uniform, timely, complete, accurate, integrated, and accessible data. This data is essential to the ability of our multidisciplinary safety partners to focus resources and monitor progress toward the Target Zero goal.

In addition, Washington State must develop an ongoing inventory system that provides comprehensive information about roadway systems, including context (what the road was originally designed to do versus what it is being asked to do now), traffic controls, presence and condition of sidewalks, roadway-crossing opportunities, connections between roadways and trail systems, and areas where speed management strategies could be implemented to reduce traffic crashes. This information is essential for local, county, and state roadway development, planning, and engineering.

Partnerships Make Traffic Records Systems a Success

The Washington Traffic Records Committee (TRC) is a partnership of federal, state, and local stakeholders from the fields of transportation, law enforcement, criminal justice, and health. The statewide TRC was created to foster collaboration and develop projects to improve the state's traffic records system. They work to achieve this through four goals:

1. Remove barriers to data sharing and integration.
2. Provide quality data, analysis, and tools to customers.
3. Sustain high levels of collaboration and acquired knowledge within the TRC.
4. Identify and secure targeted investments to sustain TRC initiatives.

Current TRC projects include:

- Development of a sustainability and funding plan for the collection, dissemination, and integration of enforcement information through the Electronic Traffic Information Processing program (eTRIP).
- Collaboration between the County Road Administration Board (CRAB) and Washington State Department of Transportation (WSDOT) to study how their two unique roadway data systems can share data and create a more seamless experience for their engineering users.
- Development of updated grant proposal requirements, gap analyses, and performance measures in accordance with National Highway Traffic Safety Administration (NHTSA) guidelines.

- Enhancement of the ability of partner agencies to collaborate on projects and exchange information.

Programs and Successes

Electronic Traffic Information Processing Program (eTRIP) Integrates Ticketing and Collision Data

eTRIP is a collaboration between WSP, WSDOT, DOL, Washington Administrative Office of the Courts (AOC), the Washington Association of Sheriffs and Police Chiefs (WASPC), and Washington Technology Solutions (WaTech). eTRIP created a seamless and integrated system for electronically gathering and distributing collision reports and traffic tickets, then tracking subsequent activity on those events. This system has been in use since 2006 and currently captures 92% of crashes and 84% of tickets issued in Washington State.

Washington's Traffic Records Data Integration Program Finds a New Home

With support from the Governor's Office, in 2018 the Washington Traffic Safety Commission (WTSC) and Washington State Department of Health (DOH) participated in a National Governors Association (NGA) Learning Lab for improving integrated traffic records. This six-month process included exploration of data governance, data sharing, and program efficiencies.

At the end of the learning lab, WTSC determined that there were other state agencies in Washington that are better resourced and experienced in managing large-scale data integration programs than WTSC.

Based on this finding, WTSC developed program specifications and requirements and conducted an invitational proposal process. The successful proposer was Washington State's Office of Financial Management (OFM) Forecasting and Research Division, with over 25 years of experience integrating data. OFM also manages an integrated education and workforce data warehouse, a justice data warehouse, and the all-payer hospital claims warehouse; these are all data warehouses that integrate data from several sources. The integrated traffic records program will officially move to OFM in 2019.

Washington's traffic information and support data systems are composed of hardware, software, and accompanying processes that capture, store, transmit, and analyze a variety of data. The following systems make up Washington's Traffic Data ecosystem:

- Driver (DOL)
- Vehicle (DOL)
- eCitation and eCrash
- Crash
  - WSDOT
  - WSP
- Roadway
  - CRAB
  - WSDOT
- Adjudication (AOC)
- Injury Surveillance
  - EMS (DOH)
  - Emergency Department (DOH)
  - Hospital Data (DOH)
  - Trauma Registry (DOH)

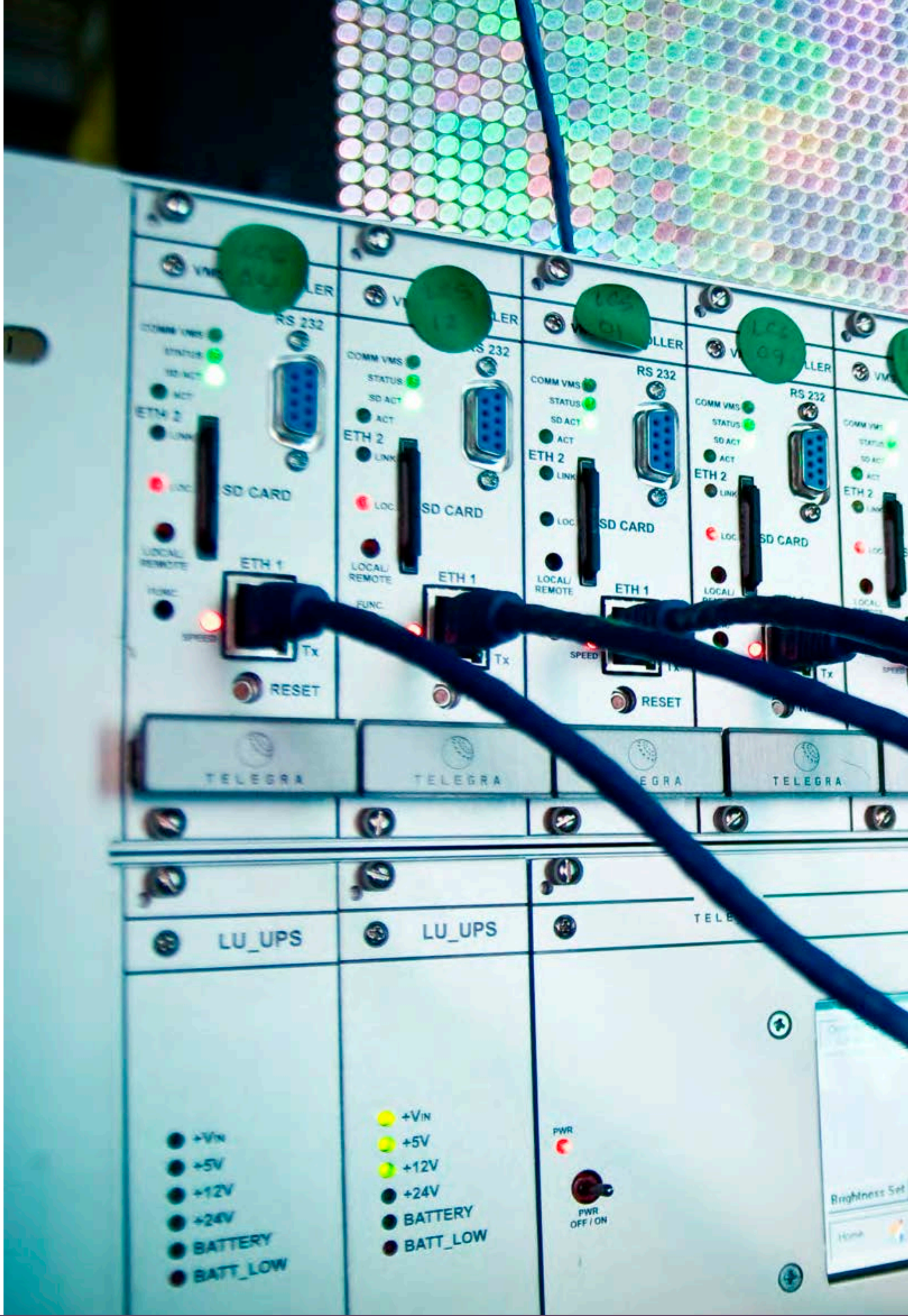
WSDOT's Crash Data Portal

The Crash Data Portal contains standard sets of reports built by data experts who have working knowledge of the crash data fields, data relationships, database structure, and the query tools. The Crash Data Portal provides access to crash data to WSDOT safety partners and the general public.

The portal is updated on a weekly basis, allowing users to access current and historical data at the state, county, or city level. Users can also query data for emphasis areas identified in Target Zero.

Linking Local and State Roads for Better Engineering Data Analysis

WSDOT and CRAB are working together to facilitate integration into their Highway Performance Monitoring System and Collision Location Analysis System by improving capabilities to provide services in support of safety data stewardship, extraction, analysis, and reporting through the use of GIS and Linear Referencing System technologies.

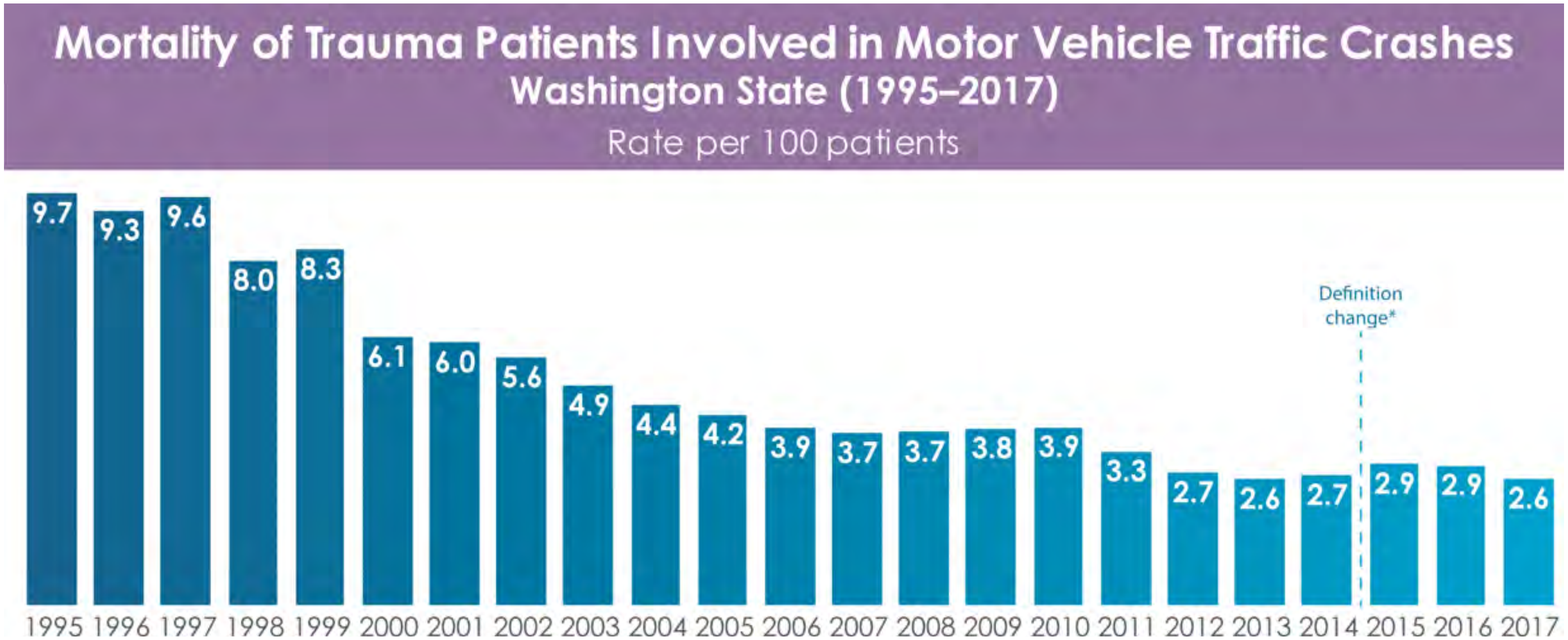


Strategies for Traffic Data Systems (TDS)		
Objective	Strategies	Implementation Areas
TDS.1. Provide quality data, analysis, and tools to customers.	TDS.1.1 Increase electronic reporting of crashes and traffic violation tickets. (R, TRC)	Enforcement, Evaluation
	TDS.1.2 Provide officers with roadside access to driver and vehicle history information from the Department of Licensing. (R, TRC)	Enforcement, Leadership
	TDS.1.3 Find ways to address and eradicate the data nuances identified in Target Zero. (R, TRC)	Evaluation
	TDS.1.4 Revise the Police Traffic Collision Report to improve crash data quality and completeness. (R, MMUCC)	Evaluation
	TDS.1.5 Develop performance measures for all core traffic data systems for each of the six system attributes (accuracy, completeness, uniformity, timeliness, accessibility, and integration). (R, TRC)	Evaluation
	TDS.1.6 Implement Data-Driven Approaches to Crime and Traffic Safety (DDACTS) model in local law enforcements agencies statewide. (R, DDACTS)	Enforcement, Evaluation
TDS.2. Remove barriers to data sharing and integration.	TDS.2.1 Create a central repository for integrated, linked data records including crash records, health (EMS, Trauma, CHARS) records, court records, licensing records, and state toxicology records. (P, CODES)	Evaluation, Leadership
	TDS.2.2 Derive a clinical classification of injury severity based on medical records to augment the investigating officer's assessment of injury severity. (P, CODES)	EMS, Evaluation
	TDS.2.3 Create connections for systems with similar or duplicate data to eliminate duplicate entry and data redundancies. (R, TRC)	Evaluation, Leadership
TDS.3. Sustain high levels of collaboration and acquired knowledge within the TRC.	TDS.3.1 Provide more frequent and enhanced traffic safety trend reporting. Present data/trends in a manner that is easy to understand and is actionable. (R, TRC)	Education, Evaluation
	TDS.3.2 Support training opportunities to enhance traffic safety data analysis and research skills. (U)	Education, Evaluation
TDS.4. Identify and secure targeted investments to sustain TRC initiatives.	TDS.4.1 Create a maintenance and support model for electronic crash and ticket reporting that further improves operations, speeds change request implementation, and enhances user support. (R, TRC)	Leadership
P: Proven R: Recommended U: Unknown		

Emergency Medical Services and Trauma Care System

Emergency Medical Services (EMS) is one of the five "Es" of traffic safety. Timely and appropriate emergency medical response to traffic crashes saves lives and reduces disabilities. Nearly 40% of all deaths from trauma occur within hours of injury, and many trauma-related deaths are preventable with timely access to an effective, organized EMS and Trauma Care System.

Washington's EMS and Trauma Care System is a coordinated system to provide appropriate and adequate care, with the goal of reducing death and disability. It strives to get the right patient to the right facility in the right amount of time. Over the past 20 years, improvements to this system have contributed to the lowest mortality rate of trauma patients involved in motor vehicle crashes in recent history, 2.6 per 100 patients in 2017 compared to 9.7 in 1995.



Note: Motor vehicle traffic crashes from 1995–2014 were defined using primary and secondary ICD-9 external cause of injury codes E810.0–E819.9, E958.5, E968.5, E988.5; 2015–2017 were defined using primary and secondary ICD-10 external cause of injury codes [V02–V04](.1,.9), V09.2, [V12–V14](.3–.9), V19(.4–.6), [V20–V28](.3–.9),[V29–V79](.4–.9), V80(.3–.5), V81.1, V82.1, [V83–V86](.0–.3), V87(.0–.8), V89.2. Data provided from the Washington Trauma Registry for patients who met inclusion criteria.

The EMS and Trauma Steering Committee

The Committee is made up of 30 members representing:

Washington State Patrol

Washinigton State Department of Licensing

Washington State Health Care Authority

Washington State Department of Transportation

Washington State Department of Social and Health Services

Office of Superintendent of Public Instruction

Emergency Medical Physicians

Trauma Surgeons

Medical Program Directors

Washington State Fire Chiefs

Washington Firefighters Council

Fire Commissioners

Emergency Medical Technicians and Paramedics

Trauma Nurses

Emergency Nurses Association

Neurosurgeons

Neurologists

Cardiologists

Washington City/County elected official

Washington Ambulance Association

Air Medical Services

Washington Poison Center

In addition to the minutes immediately following an injury, a patient's outcome is also dependent on prevention activities, hospital, and rehabilitation care.

Data-driven EMS and Trauma Care System

Washington's EMS and Trauma Care System pursues both forward-thinking strategies as well as decisions based on empirical data, recognizing these as critical to continued success. Gathering, analyzing, and archiving EMS and trauma data supports an evidence-based EMS and Trauma Care System. This helps the system realize its full potential, and continue to provide favorable outcomes for injured patients.

Washington State collects data on the care provided by EMS and the hospital-based providers treating the patient. There are three important points of analysis:

- **On-scene time.** The amount of time the patient remains on the scene after the arrival of EMS.
- **Patient destination.** Whether the patient was transported to the appropriate level of trauma hospital.
- **Patient outcome.** Whether or not the patient survived.

These three criteria allow analysts and policy-makers to evaluate the of effectiveness of pre-hospital EMS and trauma care.

The data are obtained from two sources:

- **Washington EMS Information System (WEMSIS).** WEMSIS collects pre-hospital data on all patients cared for by emergency medical personnel.
- **Washington Trauma Registry (WTR).** The WTR collects demographic and clinical data only on trauma patients at trauma-designated hospitals.

WTR is an established registry that was started in the early 1990s and is used for quality improvement of the Trauma Care System.

WEMSIS is relatively new by comparison, starting in the late 2000s. In the last few years, the focus on WEMSIS has been to clean the data, check data for completeness, produce quality reports, and validate data. Moving forward, WEMSIS's focus will be validating and linking data sets. These efforts will give a more complete picture of patient care and outcomes in the state of Washington.

Partnerships Ensure Ongoing Success

The Washington EMS and Trauma Care System has played a strong role in traffic safety through injury prevention, emergency medical services, and trauma activities. Much of this success can be attributed to the system being built upon a diverse group of health care professionals and industry experts. The Washington Traffic Safety Commission is a key partner of the Washington EMS and Trauma Care System. These partners and groups have continuously worked to address the complex political, economic, logistical, legal, and clinical issues associated with trauma care in the state. Addressing these challenges in a collaborative approach allows Washington to continue reducing the number of fatalities and long-term effects of trauma related to motor vehicle crashes.

Strategies for EMS and Trauma Care System (EMS)		
Objective	**Strategies**	**Implementation Areas**
EMS.1. Reduce injury deaths and hospitalizations through EMS response and access to trauma care.	EMS.1.1 Promote adequate distribution of Designated Trauma Centers across the state to ensure appropriate access to trauma care. (P, META).	EMS
	EMS.1.2 Promote that all major trauma patients are transported to the highest appropriate level of designated trauma center within a 30-minute transport. (R, DOH)	EMS
	EMS.1.3 Promote injury prevention programs that reduce traffic related injuries and death. (R, LIT)	Education
	EMS.1.4 Promote improvements in EMS on-scene arrival responses that are within state requirements. (R, DOH)	EMS
	EMS.1.5 Promote increasing enforcement and public understanding of the "move-over" law. (U)	Education, Enforcement
	EMS.1.6 Encourage EMS access in engineering development plans. (U)	Engineering, EMS
EMS.2. Improve communication and data capacity.	EMS.2.1 Support seamless communications capabilities among EMS, law enforcement, and fire services agencies through interoperability. (R, NCHRP)	Enforcement, EMS, Leadership
	EMS.2.2 Support the Washington State EMS and Trauma Care System with a statewide robust pre-hospital database with standard definitions and EMS agencies reporting data. (R, NCHRP)	EMS, Evaluation
	EMS.2.3 Increase reporting to WEMSIS. (R, NCHRP)	EMS, Evaluation
	EMS.2.4 Explore the use of WEMSIS data for inclusion with the integrated traffic records program. (R, WTSC)	EMS, Evaluation, Leadership
	EMS.2.5 Promote Public Health Data Interoperability (PHDI) initiative to integrate and link data from all Department of Health data systems. (R, DOH)	Evaluation, Leadership
P: Proven R: Recommended U: Unknown		

Evaluation, Analysis, and Diagnosis

Traffic safety programs achieve success by addressing the factors contributing to crashes. To be most effective in reducing future crashes, Washington uses evaluation, analysis, and diagnosis. This helps us understand what is occurring – or has a high probability to occur – on our roads, based on our understanding of road safety performance. It allows us to identify measures, target investments, track performance, and determine the effects of our efforts.

Washington's Evaluation, Analysis, and Diagnosis approach is recognized nationally as the "Fifth E" of road safety, because the fifth E leads to improved decision-making. Targeted, data-driven decisions allow us to select the appropriate strategies within the other Es: education and outreach, enforcement, engineering, and EMS. Target Zero partners use this information to increase the return on our investments by prioritizing activities and approaches in support of Target Zero goals. Ultimately, this improves the likelihood of achieving our goal of zero fatalities and serious injuries.

Target Zero provides the foundation for partners to allocate resources toward reducing fatal crashes, as well as strategically addressing fatality and serious injury targets. Each year, these targets are set by the Washington State Department of Transportation (WSDOT) and the Washington Traffic Safety Commission (WTSC) through a formal process required by federal law and are submitted in the annual Highway Safety Plan (HSP) report (prepared by WTSC) and the annual Highway Safety Improvement Program (HSIP) report (prepared by WSDOT). WTSC reports progress with their safety programs to the National Highway Traffic Safety Administration (NHTSA); WSDOT reports progress to the

Definitions for Evaluation, Analysis, and Diagnosis of Traffic Safety

	Definition	Example
Evaluation	Assess the big picture or categories of data to evaluate performance against a pre-determined set of criteria. For Target Zero, this means looking at whether or not we met targets for traffic-related fatalities and serious injuries within our priority areas. Each agency may set individual targets or criteria that would indicate a need to take some action. If a location or factor is not meeting expectations, it is identified for analysis.	We find that a specific roadway has more crashes at intersections than we would expect for similar roads.
Analysis	Study the location of factor in depth, using different means or methods in order to interpret the data and understand why a factor or location is particularly high. For instance, using crash statistics to help us understand why crashes are reducing, staying the same, or increasing.	We analyze the data to determine that the majority of those crashes are related to impaired driving.
Diagnosis	Identify contributing factors to an increase or decrease in crashes, similar to the way that a doctor diagnoses patients for the root cause of their symptoms. Done well, diagnostics help us understand the factors leading to a crash or series of crashes.	We diagnose that the problem is coming from bars in the local area, with two locations in particular that are known to overserve.

Federal Highway Administration (FHWA). WSDOT also collaborates with the state's 13 metropolitan planning organizations (MPOs) and Regional Transportation Planning Offices (RTPOs) as part of the annual target setting process. For more information on the targets, please see Appendix I: Performance Based Goals.

Local agency and WSDOT infrastructure projects to address Target Zero priorities are selected and ranked for HSIP funding. HSIP projects addressing Target Zero priorities are then included in the Statewide Transportation Improvement Program. A core metric of this ranking and inclusion is the ability of the investment to reduce the number of fatalities and serious injuries.

Using Data to Measure Performance

By using a common set of metrics, all the safety partners in the state are able to work together toward the same goal: reducing fatalities and serious injuries to zero by 2030. Partners use these metrics to set priorities and identify strategies that are targeted toward the common goal. We use these same measures to track performance over time, and to provide accountability to the public we serve. We also set targets so we can quantify what constitutes progress.

Evaluation: Looking at the Big Picture

The evaluation of the roadway system in Washington provides the foundation for the emphasis areas and priorities in Target Zero. This provides the big-picture look at what we need to focus on and how performance in these areas has changed over time.

Evaluation also enables us to then focus in on the contributing factors to crashes.

- **Human factors** represent the people driving, walking, and biking on the public roadway network. There is a particular focus on user capability, limitations within the road system, and risky behaviors.
- **The vehicle** represents the motorized vehicle, how it is designed and operated, and its safety features (for example, motorcycles and heavy trucks).
- **The environment factors** include the road system design, context, and cooperation. This also includes, for example, the safe systems approach used for designing and operating road facilities. For more information, see the "Safe Systems Approach" on page 192, or Appendix K: Safe Systems.

The emphasis areas, categorized as High Risk Behavior, Crash Type, and Road Users in Target Zero, reflect these factors. Risky behavior includes, for example, impairment and distraction. Crash types include intersection or lane departure crashes. Finally, the different user groups on our system involved in crashes include vulnerable users (people walking, biking, or using motorcycles) and drivers of particular vehicle types such as heavy vehicles. We look for patterns and use the safety (geometric, road user, traffic, crash, etc.) data to identify the contributing factors in these crashes. When we do find a significant and recurrent pattern, and believe we can address the contributing factors, then we select a countermeasure to address them—if one exists.

These factors help us to develop meaningful categories of focus areas, evaluate them to determine the magnitude and nature of these outcomes, and ultimately to set priority areas (see page 11). This information is used to identify statewide, region-specific, or even corridor- or location-specific priorities and specific strategies that can be used as interventions to reduce fatalities and serious injuries across the roadway system.

For instance, strategies include:

- High visibility enforcement (HVE) campaigns that focus on corridors with many distracted driving and impaired driving crashes.
- Barrier systems that address the severity of run-off-the-road crashes.
- Education programs to teach safe crossing skills to young pedestrians, as well as driver safety education courses for new drivers and chronically high risk drivers.

Evaluating each of these emphasis areas, we can also assess trends in the data. Trends help us to understand whether the fatalities and serious injuries in particular types of crashes are reducing, staying the same, or increasing. This helps us develop projects and programs to address priorities. As stewards of the system, we want to understand whether our interventions are effective and where a shift in our approach would be more effective in the overall reduction of serious injuries and deaths.

Analysis: Understanding Safety Performance Characteristics

Analysis allows education and outreach, enforcement, engineering, and EMS staff to assess how individual locations perform relative to similar locations across the state. This enables those working in injury prevention, enforcement, and education to identify characteristics of users and circumstances of risky behaviors, which in turn strengthens our ability to focus our efforts using specific strategies that are proven effective in those conditions.

For example, WSDOT may analyze the system to identify locations and the characteristics of those locations where more intersection angle crashes involving fatalities and serious injuries are occurring, compared to similar facilities, as part of a roundabout intervention category. WSP might identify locations based on the percentage of speed in excess of 10 miles per hour along with other factors to prioritize corridors for emphasis patrol. DOL might identify priority areas based on total DUI arrests that are related to a particular location over-serving alcohol.

While all partners use analysis, in the area of engineering, dramatic change has occurred with the Highway Safety Manual (HSM), a national document from the American Association of State Highway Transportation Officials (AASHTO). It forms the key toolbox for safety analysis in roadway planning, design and operations. With this toolbox, state and transportation professionals can use quantitative methods and human factors to analyze and evaluate corridors, locations, and projects throughout planning, programming, project development, construction, operations, and maintenance activities in a manner not available before.

Diagnosis: Digging Deeper into the Data

Diagnosis focuses on the factors believed to be contributing to the severity of the crash, types of crashes, and crash patterns. This requires a more thorough and detailed review than the analysis. This in-depth review allows partners to make data-driven decisions about how to target specific characteristics of crashes that are associated with fatalities and serious injuries.

Data-driven decision-making begins with an understanding of:

- What constitutes acceptable or less-than-acceptable safety performance?
- What can we do to reduce the number and severity of crashes?
- What is contributing to the level of safety performance in the first place? This is the most important aspect of good decision-making.

Why is diagnosis important? For example, a doctor does not give a prescription without first understanding the symptoms and conditions that the patient is experiencing, and how these are different from normal expectations for health.

Similarly, when we analyze the roadway, we first need to understand what is contributing to the crash risk, and whether or not the level of crash potential is in excess of what would be expected for that type of roadway. For instance, we will expect different crash numbers and types for a busy interstate highway with high speed and no pedestrians, compared to those of a quiet residential street with low speeds and many pedestrians.

Using Data to Improve Highway Safety

Having diagnosed the contributing factors (human, vehicle, and environment) and crash types associated with deaths and serious injuries, our next step is to develop approaches to address the crash outcomes through the selection of countermeasures proven to reduce fatal and serious crashes for the type of crashes occurring or predicted to occur at a given location.

Re-evaluate and Evolve our Approach as our Technical Abilities and our Challenges Change

What we know about the science of highway safety continues to evolve, as does our knowledge of projects and programs to address crash outcomes. The conditions on the road are evolving as well, such as the increase in automated technology. See "Cooperative Automated Transportation" on page 183 for more information.

It is important that we evaluate and then adjust for both the positive and negative results we see. We will not improve, and we will not achieve our Target Zero goal, if we don't address the interventions that have resulted in less-than-successful outcomes and if we do not maintain data-driven and science-based approaches. To achieve Target Zero, we also need to be proactive in the prevention of crashes associated with high severity injuries. While we recognize we can't prevent all crashes, we can implement treatments (systemic) that are proven to reduce the potential of deaths and serious injuries.

Diagnostics Involve a High Level of Detail to Find Crash Patterns

This crash diagram and data table are examples of the level of detail involved in diagnosis. In considering a location with 23 crashes, the engineer would, for example, assess at minimum the following data, along with other related information:

First crash type	
Entering at angle	14
Left turn opposite direction	5
Run off the road	3
Rear end	1

Contributing circumstances	
Did not grant right-of-way to vehicle	12
Disregarded STOP sign	5
Exceeded reasonable safe speed	2
Improper turn	1
Inattention	2
Impaired by alcohol	1

Crash injury severity	
Fatal injury crash	1
Serious injury crash	2
Evident injury crash	4
Possible injury crash	5
Property damage only crash	11

Using Roadway Characteristics to Identify Locations for Interventions

In the past, we evaluated safety performance in terms of reported crashes: data that represents the past experience. For example, the safety performance of an intersection used to be based solely on crash history over a very short time frame. A location that experienced multiple high severity crashes over this short time would be given priority over one that might be experiencing a more consistent and higher longer-term trend, but had fewer high severity crashes during the range of years when we made project or program selections.

This type of approach results in investments at locations that will not have a major overall effect: if nothing had been done at many of these locations, the crashes would have reduced anyway. In other words, these high-priority locations were not all high-priority locations in reality. Statistically, this is called regression to the mean, but from a practitioner's perspective, this means that investment approaches that solely rely on crash history would not be the best use of limited resources.

Target Zero partners are using more comprehensive and scientifically rigorous analysis methods in research and analysis, which increases the likelihood that investments are made in highest priority locations.

Our Countermeasures Come from National Sources

We have several tools for evaluating countermeasures and their potential to reduce crashes and injury severity. These are referred to as crash modification factors (CMFs) and are used to project the potential outcomes and to compare countermeasure effectiveness for engineering in the FHWA Crash Modification Clearinghouse, or behavioral issues in NHTSA's Countermeasures that Work. See Appendix G: Strategy Definitions and Criteria for more information on countermeasures and their sources.

For example, WSDOT is using the AASHTO Highway Safety Manual Predictive Methods, which incorporates the characteristics of a roadway. These tools allow professionals to determine the potential change in crash frequency and severity associated with a change in the characteristics of the roadway environment. The output from these methods are very helpful in making decisions related to different alternatives (AASHTO, 2010). WSDOT is also actively engaged in projects and activities that support the future updates to this manual.

Predictive Methods and Tools

In addition, Washington's success in reducing fatalities and serious injuries has also brought a new challenge. As fatal and serious injury crashes occur further apart in time and less densely at particular locations or corridors, it becomes increasingly more difficult to identify patterns and specific locations for treatment with some level of certainty. Use of predictive methods and tools that focus on expected trends based on similar roadways are necessary to overcome this challenge. WTSC and WSDOT have used these approaches successfully since the mid-1990s, and will continue to build on them for future analysis.

Meaningful and Usable Data for Partners

With a more proactive, predictive, and systemic approach comes the need for data to be more integrated and accessible to users. Many Target Zero partners use information to identify and address their current safety business needs. In the past, organizations were able to develop effective programs and projects relying only on their own data.

The many competing needs of different users of our road system and the complex nature of traffic safety requires integration of many different data sources to support successful multidisciplinary approaches to achieve Target Zero. For example, in considering an assessment of traffic barriers such as guardrail, an analyst can link data about the roadway characteristics, maintenance efforts, and asset management-related elements in order to optimize decision making for these devices. In the area of impaired driving, linking toxicology reports with crash records is key in assessing changes across time and the effects of legalizing cannabis, for example.

In 2012, the federal The Moving Ahead for Progress in the 21st Century Act (MAP-2)1 legislation directed FHWA and NHTSA to require state and local safety partners to work collaboratively in the development and implementation of the Strategic Highway Safety Plans, such as Washington's Target Zero. MAP-21 requires federally funded state programs to develop a more integrated, multidisciplinary, and multiagency safety program, across different modes of transportation.

Diagnostics Focuses our Countermeasure Selection

The diagnostics guide us in our treatment. For example, if the primary contributing factor to crashes during late Friday and Saturday nights is speeding, and through our analysis we have found that a high frequency of speeding is occurring during that same time, then an enforcement campaign that targets excessive speed at those times could be more effective than an engineering solution that modifies the highway for all drivers at all times.

On the other hand, if we were to see excessive speed in a residential area, and we also knew that the road was designed for higher speeds and mid-20th-century land use, then permanent traffic calming devices like a roundabout might be appropriate.

We can also select multiple countermeasures when primary and secondary contributing factors indicate that collectively they will reduce the fatalities and serious injuries at a particular location or on a corridor.

Washington is a pioneer and national leader in a partnership style that promotes collaboration among experts from many fields and levels of government in order to achieve the optimal solutions to highway safety issues. Our state's highway safety programs often include the coordinated use of education and outreach, enforcement, engineering, and EMS. For example, a distracted driving campaign might include education campaigns from WTSC, high visibility enforcement by WSP, and rumble strip installation by WSDOT.

Expand the Evaluation, Analysis, and Diagnostic Skills of Target Zero Staff

To be most effective in the evaluation, analysis, and diagnosis of fatal and serious injury reduction opportunities, Target Zero partners must provide training and specialized staff members. We need this skilled workforce to provide services in the overlapping and increasingly complex field of highway, safety education and outreach, enforcement, engineering, and EMS. Staff such as statisticians, epidemiologists, human factors experts, and roadway safety engineers are required to keep up with increasingly analytical and technical needs, as well as with scientific developments in their fields.

Choose Investments that Benefit the Entire System

The value of safety investments must be considered at both the local and system levels. This is important because high costs on one project or program may prevent us from doing other projects and programs at other locations. For example, spending $40 million to build an interchange at a single location, when a $3 million roundabout would reduce the same amount of fatalities and serious injuries, would not provide greater benefit for that location, and would in fact detract from improvements on the entire system. If we build the $40 million interchange, then we forgo $37 million in safety investments that we could have used to target other parts of the system: $37 million that would have saved lives and reduced serious injuries.

Strategies for Evaluation, Analysis, and Diagnosis (EAD)		
Objective	**Strategies**	**Implementation Areas**
EAD.1. Implement the Highway Safety Manual (HSM) recommended safety analysis methods.	EAD.1.1 Utilize the HSM Predictive Method as part of project development and operation of infrastructure projects. (P, AASHTO)	Engineering, Evaluation
	EAD.1.2 Integrate requirements of safety analysis as part of standard workflow, work products, and deliverables as part of documentation requirements. (R, FHWA)	Evaluation, Leadership
	EAD.1.3 Provide training in use of the HSM safety analysis methods. (P, AASHTO)	Engineering, Evaluation
EAD.2. Assess performance across emphasis areas as part of the decision-making process.	EAD.2.1 Hire and train highly capable data analysts, statisticians, epidemiologists, GIS analysts, and other data professionals. (R, WSDOT)	Evaluation, Leadership
	EAD.2.2 Integrate results of HSM Predictive method analysis into criteria for project selection and prioritization. (P, AASHTO)	Engineering, Evaluation
EAD.3. Collect and manage spatial and temporal characteristics of roadway, traffic volume, and crash data.	EAD.3.1 Modernize mainframe systems and implement a statewide linear referencing system framework for the public roadway network that can be used by all public agencies in the state. (R, FHWA)	Evaluation
	EAD.3.2 Develop and institutionalize data management practices that meet industry standards and enables data integration across all public roadway related data sets. (R, FHWA)	Evaluation, Leadership
	EAD.3.3 Implement and institutionalize sustainable data collection processes such as mobile LIDAR that allows data to be collected once and used many times across agencies for diverse needs. (R, WSDOT)	Evaluation
EAD.4. Implement evaluation of all safety-specific investments as part of general business practice.	EAD.4.1 Establish and use existing data analyst expertise to support data-driven business decisions and conduct evaluation of safety efforts. (R, WSDOT)	Evaluation
	EAD.4.2 Support workforce development to advance the skills of safety data analysts, statisticians, epidemiologists, and GIS analysts that support programs, projects, and activities aimed at reducing fatalities and serious injuries. (R, WSDOT)	Evaluation, Leadership
P: Proven R: Recommended U: Unknown * These strategies were not voted on at the Target Zero Partners meeting		

Cooperative Automated Transportation

Includes Automated Vehicles

Advances in vehicle automation, connectivity, electrification, and shared mobility are transforming transportation. There are many potential benefits and opportunities associated with the implementation of connected and automated transportation, such as reduced crashes, better use of existing infrastructures and systems, reduced need for new infrastructure, improved energy efficiency, and improved access for people unable to hold a driver license.

However, it is important that we provide stewardship and guide the implementation to advance the positive impacts and minimize possible negative impacts such as increased congestion, inequitable access, and workforce impacts. From a Target Zero perspective, the most important Cooperative Automated Transportation (CAT) benefit is the potential for saving lives on our roadways.

According to the National Highway Traffic Safety Administration (NHTSA), human error is a contributing factor in 94% of crashes. While many Target Zero countermeasures focus on changing driver behavior for this reason, the addition of automation will begin to transition driving tasks that were once performed by the driver to the vehicle. As the role of the human driver is reduced, crashes that are a result of human error should also reduce; the vehicle will provide support to impaired, distracted, drowsy, and inexperienced drivers on our roads. Although not all crashes can be prevented through the use of automation, Washington State can move significantly closer to Target Zero.

Automated Vehicles are Already on the Road

Most people think of automated vehicles (AVs) as driverless, but there are various levels of automation in vehicles, including many cars that are on the road today. The Society of Automotive Engineers (SAE) has established Levels of Automated Vehicles (SAE J 3016-2018). The illustrative graphic below is based on this standard.

Vehicles with Level 1 and 2 automation are already on the road. Advanced driver assistance systems (ADAS) such as rear view cameras, forward collision warning and auto-braking, lane departure warning, and blind spot detection will soon be as common as backup cameras.

VEHICLES WITH AUTOMATION

LEVEL	0 None	1 Assistance	2 Partial	3 Conditional	4 High	5 Full
What car does	Nothing	Assists; Accelerate, brake or steer	Assists; Accelerate, brake and steer	Everything for short periods of time	Everything restricted operating environment	Everything
What driver does	Everything	Everything with some assistance	Everything with more assistance	Remain alert ready to resume control	Nothing restricted operating environment	Nothing

Source: Johanna Zmud, Texas A&M Transportation Institute

Additionally, there are Level 3–4 AVs currently being deployed in limited capacities for low speed shuttles and shared ride type applications, providing the public with increased opportunities to experience the technologies.

Real-world Benefits of Advanced Driver-assistance Systems

Highway Loss Data Institute (HLDI) and Insurance Institute for Highway Safety (IIHS) study the effects of advanced ADAS features by comparing rates of police-reported crashes and insurance claims for vehicles with and without the technologies from 23 states:

Insurance Institute for Highway Safety (IIHS) and Highway Loss Data Institute (HLDI). (May 2018)

Forward collision warning

- ▼ 27% Front-to-rear crashes
- ▼ 20% Front-to-rear crashes with injuries
- ▼ 9% Claim rates for damage to other vehicles
- ▼ 16% Claim rates for injuries to people in other vehicles

Forward collision warning plus autobrake

- ▼ 50% Front-to-rear crashes
- ▼ 56% Front-to-rear crashes with injuries
- ▼ 13% Claim rates for damage to other vehicles
- ▼ 23% Claim rates for injuries to people in other vehicles

Lane departure warning

- ▼ 11% Single-vehicle, sideswipe and head-on crashes
- ▼ 21% Injury crashes of the same types

Blind spot detection

- ▼ 14% Lane-change crashes
- ▼ 23% Lane-change crashes with injuries
- ▼ 7% Claim rates for damage to other vehicles
- ▼ 8% Claim rates for injuries to people in other vehicles

Rear automatic braking

- ▼ 62% Backing crashes
- ▼ 12% Claim rates for damage to the insured vehicle
- ▼ 30% Claim rates for damage to other vehicles

Rearview cameras

- ▼ 17% Backing crashes

Rear cross-traffic alert

- ▼ 22% Backing crashes

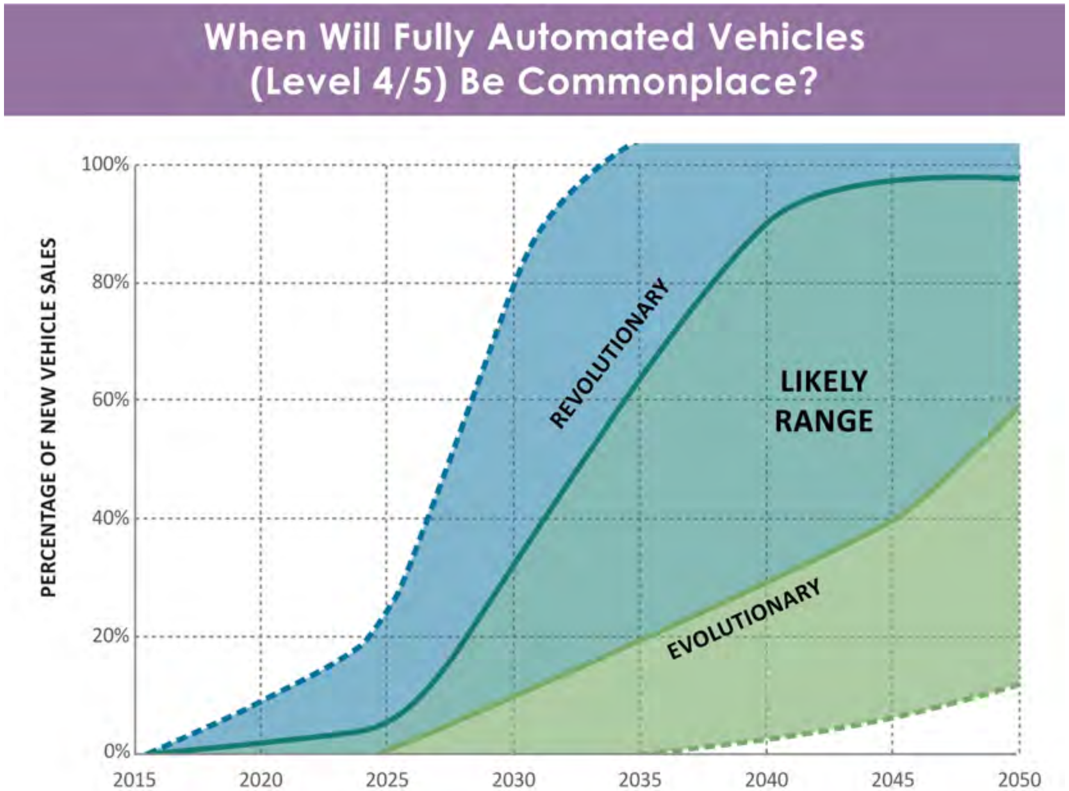
There is currently a gap in the public understanding of ADAS functions and limitations: how they should be used and how they can benefit drivers. This information gap needs to be addressed to ensure the anticipated safety benefits are achieved. Many drivers have these systems in their cars but may not have received adequate instructions from the dealership or the previous vehicle owner. Rental cars with equipment that the drivers are unfamiliar with could create confusion and contribute to increased crashes during some driving situations.

Another possible issue to consider is the potential for over-reliance on ADAS, when drivers stop paying adequate attention because it feels like the car is driving for them, or monitoring items that the drvier should be payhing attention to. Similar to the introduction of seat belts in the 1960–70s and car seats in the 1980s, the federal government regulates the design of these safety features, but people need education to guide the safe adoption of the new technology.

Public Perception

A few studies have found that some people are not yet comfortable with the idea of riding in Level 4 or 5 AVs. Following two high-profile crashes in the first half of 2018 involving vehicles with Level 2 or 3 automated technology, some consumers lost trust in the concept of Level 4 and 5 AVs. In January 2019, 71% of U.S. drivers said they would be afraid to ride in a fully self-driving vehicle, up from 63% at the end of 2017, according to one annual AV survey. However, when consumers experience riding in a vehicle equipped with automated technology, they may gain confidence in the technology.

To increase public trust, it will be critical for manufacturers to have robust and verifiable testing processes to demonstrate the safety of AVs. The public will need assurance that vehicles can consistently handle these edge cases, situations that rarely happen but can be serious if the vehicle does not react correctly.



Source: ITS America – Data and the Digital Highway, ITS America Forum, Nov 5th, 2018

Full Automation Scenarios

The adoption rate for Level 4 and 5 AVs predictions represented in the graphic on this page are based on two high-disruption scenarios. These project the possible percentage of new car sales 2016–2050 that have Level 4 and 5 automation. Under the Revolutionary scenario, there are technology breakthroughs, regulatory resolutions, and shared mobility options that are much lower cost than personal vehicle ownership, along with rapid adoption. In the Evolutionary scenario, technology development and rollout is much slower, premium cost vehicles are owned by individuals at a lower rate, and the adoption rate is much slower.

Developing the Regulatory Landscape

Traditionally, the U.S. Department of Transportation is responsible for regulating all motor vehicle design, safety, and equipment. Meanwhile, state governments have assumed responsibility for regulating human drivers, establishing traffic laws, and other aspects of motor vehicle operation. The regulatory landscape for AVs is still uncertain, with pending legislative action at the federal level. State and local governments are left to consider taking action within their historical roles.

The Current Political Framework in Washington State

In June 2017, Governor Inslee signed Executive Order 17-02, creating an Autonomous Vehicle Work Group and established a self-certification process for AV manufacturers to enable pilot programs for “the safe testing and operation of autonomous vehicles,” with or without human operators present. As of June 1, 2019, 11 companies have self-certified to conduct testing and operate AVs on the roads in Washington State.

The following year, the Legislature directed the Washington State Transportation Commission (WSTC) to “convene an executive and legislative work group to develop policy recommendations to address the operation of autonomous vehicles on public roadways in the state.”

The Autonomous Vehicle Work Group established an Executive Committee that includes state government agencies, Legislators, private sector, industry, and non-profit organizations. Five subcommittees were created to assess challenges and needs, then generate recommendations to the Executive Committee for consideration.

The five subcommittees, with lead agencies, are:

- **Licensing.** Lead agency: Department of Licensing (DOL).
- **Liability.** Lead Agency: Office of the Insurance Commissioner (OIC).
- **Infrastructure and Systems.** Lead Agency: Department of Transportation (WSDOT).
- **Safety.** Lead Agencies: Washington Traffic Safety Commission (WTSC) and Washington State Patrol (WSP).
- **System Technology and Data Security.** Lead Agency: Washington State Office of the Chief Information Officer (OCIO).

Recommendations are geared to enable Washington State to address the public policy changes necessitated by the emergence of AV technology in an informed, thorough, and deliberate manner, and are provided to the WSTC, which is responsible for submitting final recommendations to the Legislature.

The work group will remain in place through 2023. More information and details on the work group’s efforts to date can be found online through WSTC’s AV Work Group (wstc.wa.gov/Meetings/AVAgenda/AutonomousVehicleWorkGroup.html).

Initial Safety Focus Areas

A major area for the WSTC AV Work Group is traffic safety. Below are some of the areas identified by the Washington State AV Work Group's Safety Subcommittee in their first few meetings in the fall of 2018.

Educating the Public

As mentioned previously, the public does not have a consistent understanding of the Level 1 and 2 safety features currently in their cars. News articles and advertisements can be confusing to the public about the vehicles' capabilities. This misunderstanding leads to confusion and potentially fatal and serious injury crashes. Key issues include:

- Who should be educating people about the benefits and limitations of today's safety features?
- What should the messages be? What are the most effective ways to distribute the information?
- How can traffic safety practitioners share the most current and accurate information with the public to help them understand the benefits and limitations of automation Levels 3, 4, and 5 vehicles.

Target Zero Partners agree these areas need further discussion.

What is a Health Impact Assessment?

A Health Impact Assessment (HIA) is a process that results in a report which identifies the potential health and safety effects of a proposed major change—such as the transformational effects of automated mobility. An HIA also provides policy and legislative recommendations to improve health and safety outcomes. It includes an emphasis on equity and identifying disproportionate impacts on historically marginalized populations.

Public Health and Equity Impacts

- The subcommittee recommended that a modified Health Impact Assessment (HIA) be done to understand the anticipated public health impacts of AVs. This will help policy makers understand the implications of various approaches before making decisions, as well as provide strategies to maximize positive impacts and mitigate negative ones. Some of the questions that may be addressed include:
- Will there be disproportionate negative impacts to disadvantaged communities?
- What are Washingtonians' concerns about AV, and how can we mitigate those concerns?
- What are the benefits and unintended impacts of more automated transportation on public health and equity?
- What might be the impact on bicyclists, pedestrians, scooters, and other roadway users?

Data Access

When a crash occurs that involves a vehicle equipped with Level 3, 4, or 5 automated technology, questions will likely arise relative to who was in control at the time of the crash: the driver or the vehicle? At lower levels of automation, where the vehicle is providing assistance, the driver is assumed to be responsible. Data security and privacy are of the utmost importance and are directly related to the safety of all persons on the road. Key issues include:

- In crash investigations, what additional data will be needed and how will it be obtained?
- Will the data also be available to establish liability and for insurance purposes?
- What data will need to be gathered for research purposes?

Target Zero Partners agree these areas need further discussion.

Preparing Transportation Systems and Services: Cooperative Automated Transportation at WSDOT

Connected and automated transportation technology is being deployed nationally and is coming to Washington's transportation system. WSDOT is working with many partners, including the WTSC, to prepare for its effective and safe deployment.

The private sector continues to make important advances in the development and deployment of AVs and connected transportation technology. This technology has the potential for both positive and negative effects on the transportation system in Washington State. This further underscores the opportunity and need for stewardship by WSDOT and its partners.

The terms used to describe this new technology have varied from connected to cooperative, and autonomous to automated, as well as others. WSDOT is attempting to lead the conversation about this technology, including building a common definition. WSDOT's recommended common definition and vision assumes that this technology is cooperative and automated. WSDOT is taking an inclusive, interdependent, multimodal, and integrated perspective of automation, hence the term Cooperative Automated Transportation (CAT).

In promoting CAT, WSDOT envisions a future where automated, connected, electrified, and shared mobility contributes toward a safe and efficient transportation system. This system emphasizes public transit and active transportation and promotes livable (walkable/bikeable), economically vibrant communities with affordable housing, and convenient access to jobs and other activity centers.

Benefits of CAT Technology

WSDOT's Cooperative Automated Transportation (CAT) program focuses on how new automated capabilities can advance the state's multimodal transportation system and enhance the communities we serve through a strategic CAT vision that emphasizes safety.

Safety. CAT technology has the potential to reduce the more than 90% of crashes that include human error as a contributing factor. As the deployment of AV technologies increases, human error related crashes are expected to decrease. Managing safety is a top priority during the challenging transition period where non-automated, partially automated, and fully automated vehicles are operating at the same time. CAT technology has the potential to reduce the 94% of crashes that include some form of human error.

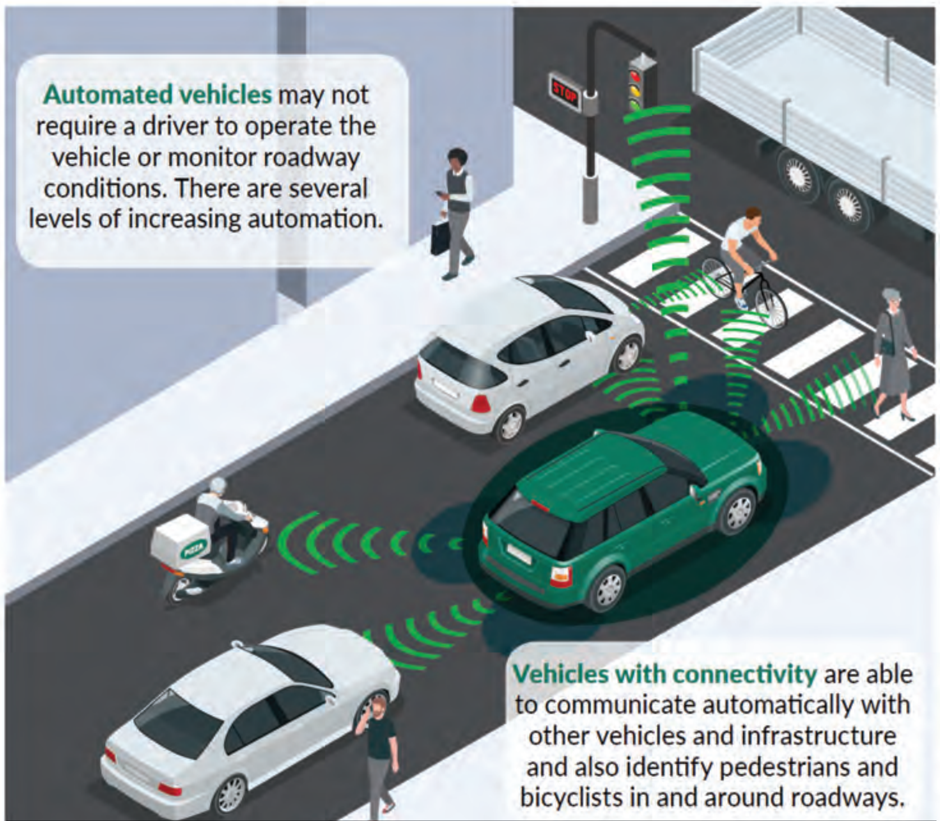
Mobility/Equity. CAT technology has the ability to increase mobility for all, including those who cannot drive, improving independence and quality of life. WSDOT is committed to supporting and enabling equitable mobility options for all communities and improving the availability of safety benefits to disadvantaged communities.

Sustainability/Environment. Vehicles communicating with each other and traffic systems along with shared mobility and electrification of fleets can help reduce congestion, crashes, and idling, providing more efficient travel and reduce emissions and Vehicle Miles Traveled (VMT). It will be critical to encourage the use of electric and shared vehicles to maximize the benefits.

Efficient travel. Technology can make our existing infrastructure and transportation systems more efficient. This can increase the number of people who can travel on an existing roadway, which helps ease congestion.

Strategic CAT Vision

- Develop a CAT policy framework considering both community and regional transportation system needs.
- Develop multimodal CAT goals, including safety, to help determine agency investment priorities.
- Create opportunities for partnerships with industry, local partners, and others.



Source: WSDOT, Cooperative Automative Transportation, 2019

CAT in Action

Examples of current and near-term CAT activities and partnerships that support safety include:

- **Winter operations.** Provide travelers real-time road and weather conditions by sharing connected vehicle data from snow plows and other systems.
- **Traffic signals.** Test and deploy equipment that increases communication with vehicles, bicyclists, and pedestrians to improve intersection safety and overall traffic operations.
- **Automated work zone vehicles.** Test how AVs can improve safety by eliminating the need for a driver in some staging vehicles.

Future opportunities may include:

- **Transit automation.** Help buses avoid blind-spot crashes with pedestrians and bicyclists.
- **Signing and striping.** Minimize the variation in roadway signing and striping and implement improvements that benefit travelers now and also prepare the system for automated vehicle needs.
- **Driver-assisted truck platooning.** Study potential for safety and efficiency benefits and reducing fuel consumption and greenhouse gas emissions.
- **Multimodal connection hubs.** Develop new infrastructure to support multimodal connections to provide safety transition opportunities between modes.
- **Traffic management.** Study how interaction between connected vehicles and infrastructure can help make traffic operations safer and more efficient.
- **EV charging infrastructure.** Expand EV charging stations in Washington to support AVs.

These strategies are a sub-set of recommendations from the following sources:

- NHTSA's Automated Driving Systems 2.0 (www.nhtsa.gov/vehicle-manufacturers/automated-driving-systems).
- USDOT's Automated Vehicles 3.0 (www.transportation.gov/av/3/preparing-future-transportation-automated-vehicles-3).
- GHSA's Autonomous Vehicles Meet Human Drivers: Traffic Safety Issues for States (www.ghsa.org/resources/spotlight-av17).

Most were voted on at the Target Zero Partners Meeting and received at least 60% support of the attendees.

Given the new and quickly evolving nature of automated vehicles, these strategies should be considered concepts for further discussion and refinement by partners and stakeholders.

Strategies for Cooperative Automated Transportation (CAT)		
Objective	Strategies	Implementation Areas
CAT.1. Educate the public and external partners to increase awareness and understanding of AVs.	CAT.1.1 Coordinate programs to educate owners and operators of Level 1-3 vehicles regarding the capabilities and limitations of the vehicles they drive and their responsibilities when operating those vehicles. (R, NHTSA)	Education
	CAT.1.2 Educate the public on how and where Level 4 and 5 AVs will be deployed, how they operate, and what to expect from AVs. (R, USDOT)	Education
	CAT.1.3 Engage with citizens. (R, USDOT)	Education
	CAT.1.4 Ensure driver education instructors are fully informed about ADAS/AV features and include this in their lesson plans. (U)	Education
	CAT.1.5 Encourage purchasing of vehicles with ADAS features for state and local fleets and provide employee training for safe and effective operation. (U)	Leadership
CAT.2. Evaluate the benefits and impacts of AV policies nationwide while encouraging AV data sharing partnerships.	CAT.2.1 Incorporate AV information into traffic violation and crash reports, including level, Operational Design Domain (ODD), and if the vehicle was under driver or vehicle control. (R, GHSA)	Evaluation
	CAT.2.2 Evaluate licensing and registration requirements in place in other states to assess the intended outcomes and whether these policies are achieving or expected to achieve those outcomes. (R, GHSA)	Leadership
	CAT.2.3 Identify data needs and opportunities to exchange data. (R, USDOT)	Evaluation
	CAT.2.4 In the event of a crash, assess how law enforcement, insurers, AVs and other third parties can share data and how that data could be beneficial for crash investigation and assigning responsibility. (R, NHTSA)	Evaluation, Leadership
P: Proven R: Recommended U: Unknown * These strategies were not voted on at the Target Zero Partners meeting		

Strategies for Cooperative Automated Transportation (CAT)		
Objective	**Strategies**	**Implementation Areas**
CAT.3. Prepare agency staff and law enforcement to support the safe operations of AV.	CAT.3.1 Assess how agency staff, law enforcement, and other third parties should engage with AVs, including how to identify and communicate with an AV on the road. Increase patrol officer awareness of best practices or procedural recommendations. (R, USDOT)	Education, Leadership
	CAT.3.2 Assess, align, and build the organizational capacity to prepare for AVs within existing organizational structures. (R, USDOT)	Enforcement, Engineering, EMS, Leadership
CAT.4. Provide an environment for safe operation of AV.	CAT.4.1 Assess infrastructure elements, such as signing and striping and the potential need for roadside communication equipment, so that they are conducive to enabling and supporting the operation of AVs. (R, USDOT)	Engineering
CAT.5. Update laws and regulations.	CAT.5.1 Identify and address existing regulatory barriers to the safe and effective operation of mobility on demand service that include AVs. (R, USDOT)	Education, Leadership
	CAT.5.2 Evaluate AV-related laws and regulations in other states and assess the intended outcomes and whether these laws/regulations are achieving or expected to achieve those outcomes. (R, NHTSA)	Leadership
	CAT.5.3 Determine whether traffic law changes or exemptions are needed to enable the safe commercial deployment of AVs. (R, NHTSA)	Leadership
P: Proven R: Recommended U: Unknown * These strategies were not voted on at the Target Zero Partners meeting		

Safe Systems Approach

The Safe Systems approach begins by examining the contributing factors of serious injury and fatality crashes. It focuses on addressing these factors directly in ways that improve outcomes for all users regardless of their mode, actions, or human conditions. The Safe Systems approach recognizes that the human body has a limited tolerance for the forces during a crash, that humans make mistakes, and that all stakeholders —roadway users, designers and managers of infrastructure, vehicle manufacturers, and others—have a responsibility to reduce fatalities and serious injuries.

Safe Systems has been implemented across a number of countries and has proven successful in reducing fatalities and serious injuries. At its core, it includes four main components: speed, infrastructure, vehicles, and users. Some agencies add post-crash care (EMS) as part of the approach. For Target Zero, Safe Systems represents a multidisciplinary approach to reduce the potential for fatalities or serious injuries, or reduce the severity of a crash if one does occur.

Safe Systems works to recognize the responsibility of all components in the system to work together towards zero fatalities and serious injuries, without placing blame. For example, the Washington State Department of Transportation (WSDOT) installs traffic barrier on the roadside because these systems reduce the severity of a crash when a driver leaves the roadway. In providing this infrastructure, WSDOT does not distinguish between the driver who swerved off the road to avoid a crash, the driver who had a heart attack, or the driver who was text messaging. Regardless of the circumstances of the crash, the purpose of the barrier is to reduce the severity of the crash.

What is the *Transportation System* in the Safe System Approach?

The transportation system includes infrastructure, vehicles, user actions and decisions, and other variables that affect people's ability to get where they need to go in a reasonably safe manner using any means of transportation. This chapter focuses primarily on infrastructure to introduce the topic of Safe Systems, and promotes systematic approaches to improve outcomes for all. It is important to recognize that within the Safe Systems approach, all stakeholders and all road users are involved in producing a system with fewer fatal and serious crashes. The other factors are discussed briefly.

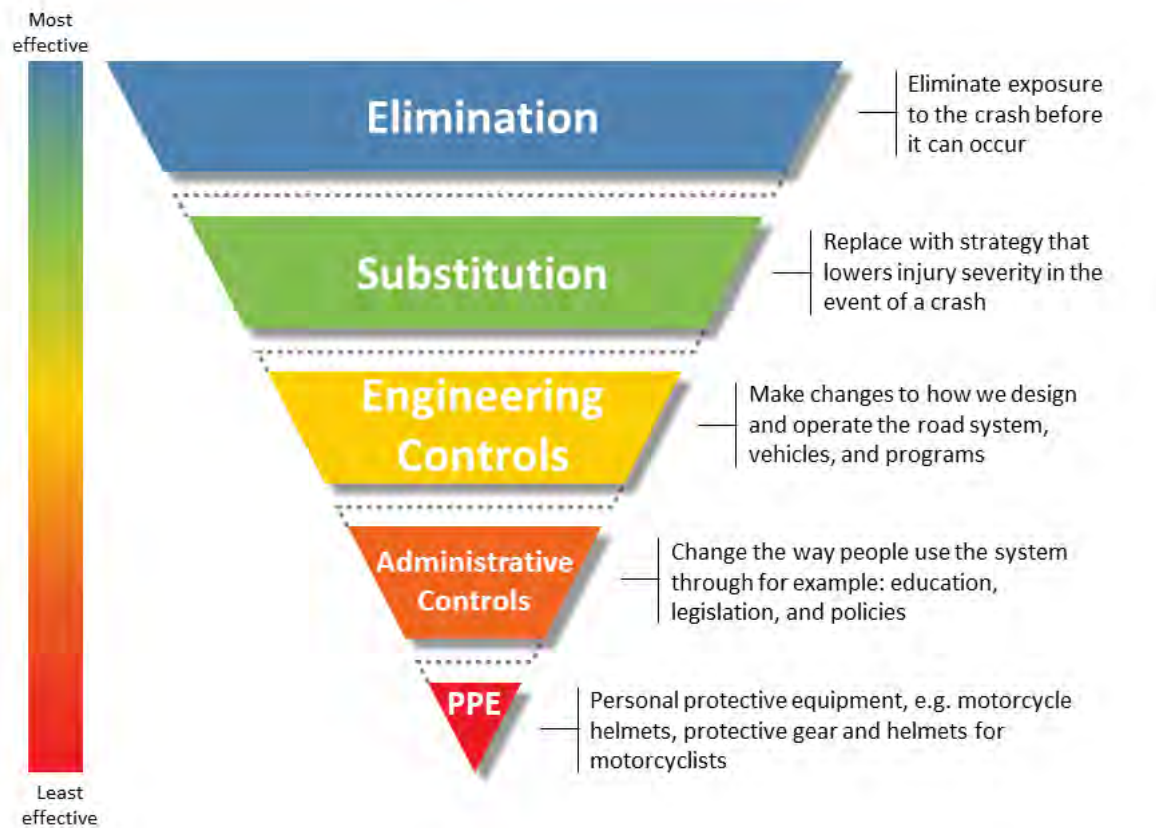
The Hierarchy of Controls, adapted from the field of workplace safety and shown in the diagram on the following page, illustrates the different approaches to user safety. The strategies that focus on elimination are at the top: these approaches are more effective in reducing fatalities and serious injuries because the events themselves are proactively addressed. In this paradigm, elimination is more efficient than substitution, substitution more efficient than engineering controls, and so on. Prioritizing efforts in this way creates a system that is generally more effective and protective. While the most effective approaches may in some cases be more difficult or costly to implement initially within existing systems, total life cycle benefits and avoided tragedies should be greater.

It is clear from this diagram and the extensive research supporting this framework that **focusing on the system itself** is more effective than user protection. Eliminating the source crash exposure is preferable to mitigating the impact of a crash.

The Safe Systems approach recognizes that a vehicle's size and the driver's operating speed, coupled with the roadway design, are factors that determine the most effective methods to reduce crash potential. It is essential to address those elements that are the primary contributing factors to crash exposure for maximum ongoing benefit. In locations where a road user may be hit by a driver, we can systematically address that exposure by providing separation or addressing it in a way that considers all roadway users. For example, a safety campaign that instructs pedestrians and bicyclists to "See and Be Seen" leaves out the existence of blind or low-vision pedestrians and the use of dark windshield tinting on vehicles. To address conditions for all vehicle types and reduce crash exposure for all roadway users, we might make systematic improvements that provide drivers with the time in which to see and respond to the presence of others using the roadway. Depending on the context and operation of the facility, these could include:

- Pedestrian-scale lighting.
- Vegetation maintenance.
- Appropriately marked or signalized crosswalks.
- Speed management treatments.

In some locations it might also be appropriate to prohibit or channelize vulnerable users from a given location, as is done on a limited-access highway.



Hierarchy of Controls for Traffic Safety, adapted from Hierarchy of Controls (National Institute for Occupational Safety and Health, 2017). Transportation system examples added to graphic.

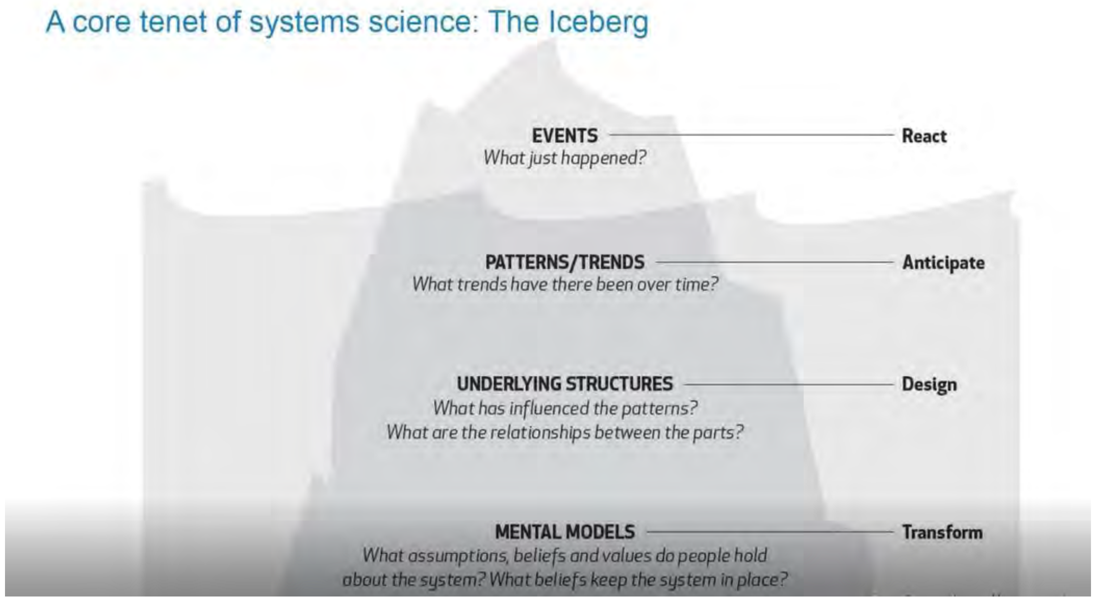
Proactive Approaches to Traffic Safety

Effective approaches to reduce fatalities and serious injuries include strategies to address existing, known crash locations, as well as proactive approaches to reduce fatalities and serious injuries at places where crashes might occur, based on the features of that location. This can be done through infrastructure planning, design, traffic operations, and maintenance.

WSDOT has proven the efficacy of this approach through its existing programs, such as ongoing efforts to reduce rural run-off-the-road crashes for motorists (see page 235). In this type of analysis, WSDOT examines the roadway system to identify features that research has shown are more likely to result in crashes. These might include certain curve types, operating speeds, or other aspects of the roadway and its usage. Engineers use this information to determine locations to implement countermeasures or strategies to proactively reduce the chances that a crash will occur for the given crash patterns and crash types at a given location.

Using data-driven safety analysis helps engineers to identify locations, specific treatments, and an overall structure to provide the maximum benefit for all roadway users.

Many Safe Systems improvements focus on vulnerable road users such as pedestrians and bicyclists. The good news is that designing to reduce exposure to potentially fatal crashes for the most vulnerable road users is a proven, effective strategy to achieve better outcomes for motorists and motorcyclists as well. This represents a shift to focus on the most effective countermeasures to reduce crash exposure for everyone, which is an evolution from a system oriented primarily around modes or numbers of specific types of users.



A systems approach rests on the science of understanding those variables and factors "under the waterline" that are not easily seen. Examining patterns, trends, underlying structures, assumptions, beliefs, and values will offer insight as to why the event happened. These issues can then be addressed.

Video Analytics and Vision Zero

The City of Bellevue is piloting a systematic approach to reducing crashes for all roadway users. Its video analytics project uses Bellevue's existing traffic cameras to identify the number and potential severity of close-call crashes at key intersections between people driving, walking, and bicycling. This insight could help the city proactively identify intersections warranting safety improvements consistent with the city's Vision Zero effort. For more information, please see page 231.

Complete Streets

Reducing motor vehicle travel demand has a direct relationship to crash outcomes. Around the world, cities that have emphasized multimodal mobility strategies around traffic safety performance for people who are walking, bicycling, and using public transportation have seen consistent reductions in traffic deaths for all roadway users. These reported reductions in fatalities among people walking and biking for these cities were partly due to the “safety in numbers” phenomenon, in which increases in the number of bicyclists and pedestrians yield a lower individual exposure to potential crashes with drivers.

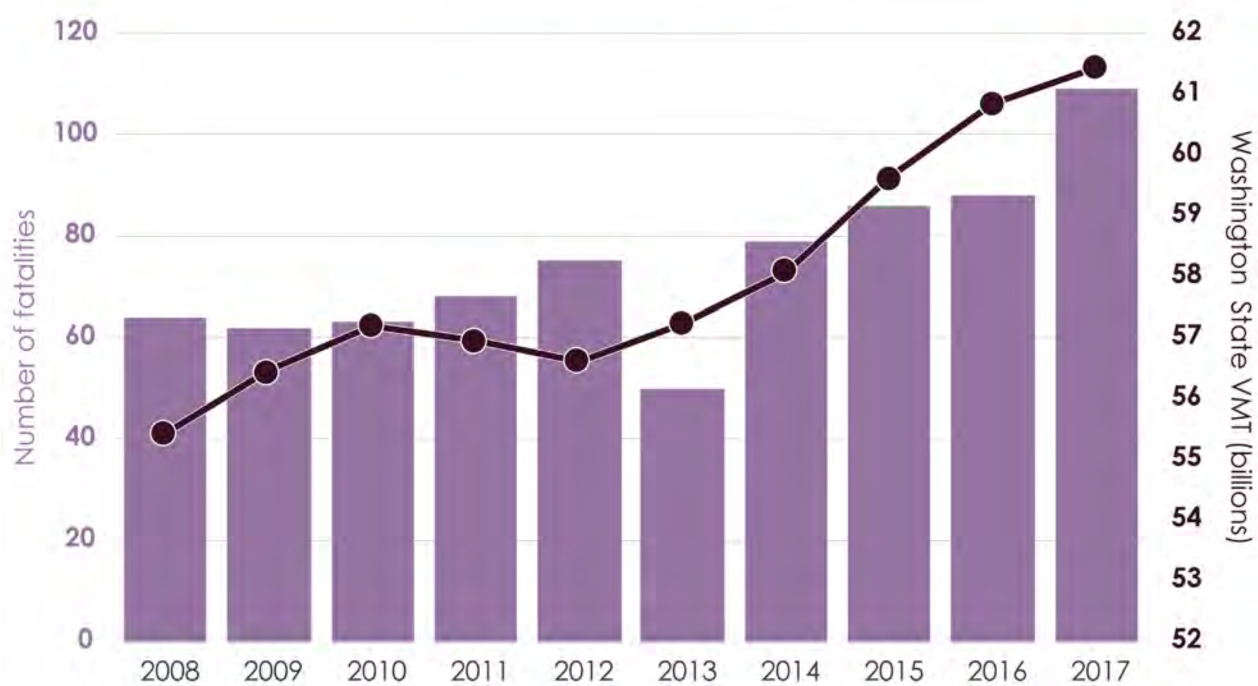
The Complete Streets approach supports safe movements of all roadway users, and demonstrates similar safety benefits. Infrastructure investments are the key element to enabling these benefits: investments in multimodal connections would reduce potential crash numbers and crash severity for all roadway users, even when the funding focuses on multimodal mobility rather than safety performance. This demonstrates the benefits of thinking systematically.

Public transportation, such as buses and light rail, is associated with very few fatalities and serious injuries. In 2017 zero crash-related fatalities of passengers or employees were reported in Washington for either urban or rural public transportation by bus and light rail, and just one serious injury. Across the United States in 2017, 16 fatalities were reported for all forms of public transportation including bus, rail, ferry, and other (such as vanpool, for example). When considering the passenger-miles traveled by different modes, the National Safety Council concluded that passengers on the nation’s bus, rail, or commuter rail systems are 40 times less likely to be involved in a fatal crash, and 10 times less likely to be involved in a crash resulting in injury.

Safe Systems Focuses on the Most Serious Outcomes, Not All Crashes

One of the fundamental principles of Safe Systems is this: Humans make mistakes and systems should be designed to provide forgiveness for those mistakes. Designs that reduce the number of—or at least lessen the severity of—tragic outcomes like fatalities and serious injuries are the most effective. Actions and decisions that increase the potential for crashes should be avoided or addressed.

Pedestrian Fatalities and Vehicle Miles Traveled (VMT)
Washington State, 2008–2017



A Driver's Peripheral Vision at 20–25 mph

A Driver's Peripheral Vision at 40+ mph

Data and Safe Systems

Using data- and science-based methods, the Safe Systems approach offers specific ways for traffic safety practitioners across all jurisdictional levels to reduce the number of fatalities and serious injuries on our roadways. The approach relies on continuously improving data systems and using consistent methodologies for collecting and cataloging to allow for data integration, evaluation, and analysis, including both crash data and infrastructure to analyze context. We must act on what we currently know about what works to reduce the frequency and severity of crashes while investing in sustainable data collection and management practices to facilitate data-driven decisions going forward.

What Does the Safe Systems Approach Include?

The design and operation of a roadway system are complex efforts that take place within the context of many decisions around transportation, land use, and other factors that affect the potential for crashes to occur. Planners, engineers, and other transportation professionals work together to develop alternative solutions to a given challenge. They carefully consider the trade offs, costs, and benefits, along with requirements set by policy, existing best practices, and emerging approaches.

Speed Control and Separation

Create a system of self-enforcing roadways: environments that cause drivers to automatically select appropriate speeds, based on the kinds of users likely to be there.

The 2008 Organisation for Economic Co-operation and Development OECD) report noted that safe speeds represent the primary pathway towards a safer transportation system. Drivers self-regulate their speed when they are cued by land use and other contextual and design elements.

Complete Streets in Vancouver, WA

Fourth Plain Boulevard in Vancouver was converted from four lanes without facilities for people walking, biking, or in wheelchairs into a street with two through lanes, a center turn lane, two bicycle lanes, curb ramps, and improved sidewalks. After this investment, motor vehicle crashes dropped 52%, and the number of pedestrian-involved crashes dropped from two per year to zero.

The Complete Streets movement supports integrating public transportation, walking, and cycling into community and transportation system planning efforts. It is based on the premise that streets need to be designed to accommodate multiple transportation modes for improved safety, mobility, and efficiency.

Roundabouts continue to reduce the potential for fatal and injury crashes throughout Washington. From 2004 to 2017 no bicyclist or pedestrian fatalities were reported at roundabouts in Washington state.

Examples of cues include:

- Lane and roadway width.
- Marked crossings, center islands, or raised medians.
- Bicycle infrastructure.
- Gateway treatments entering rural towns.

This principle also makes use of different levels of separation between vulnerable users and vehicles traveling at high speeds. Where land use supports higher operating speeds, more separation is called for so vulnerable road users aren't right next to the high-speed traffic and so drivers traveling in opposite directions are separated.

Approaches in this area include speed management policies that emphasize operating speeds compatible with land use and road user characteristics to minimize injuries and fatalities, as well as increased separation for vulnerable active transportation uses through physical barriers, distance, or time.

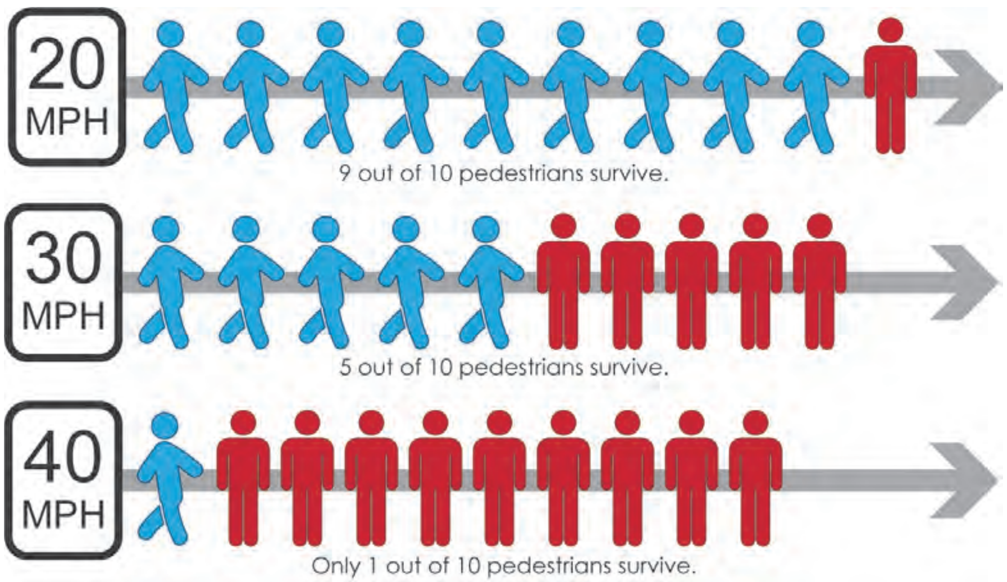
Examples of approaches include:

- An all-walk phase at a signal in a location with high levels of pedestrian traffic.
- A protected bike lane with a bicycle traffic signal and a red left-turn arrow for drivers to prevent turns across the bike lane and adjacent crosswalk while bicyclists and pedestrians have a green signal/WALK sign.
- Median treatments on an arterial or highway.
- A shared-use path separated by concrete barriers from people driving at highway speeds.
- A planter strip, parking lane, or protected bike lane acting as buffers between the vehicle lane and the sidewalk on a busy arterial.

A number of national studies make it clear that focusing on lowering operating speeds is essential to reducing the number and severity of crashes, and saving lives for all roadway users. However, lowering speed limits is not an effective strategy if the roadway is designed for a higher operating speed than that which is appropriate given the land use and mix of roadway users. Some drivers will continue to respond to the environmental and contextual cues to travel faster than is safe for all roadway users. A multidisciplinary approach will apply design, operations, and enforcement to achieve desired operating speeds.

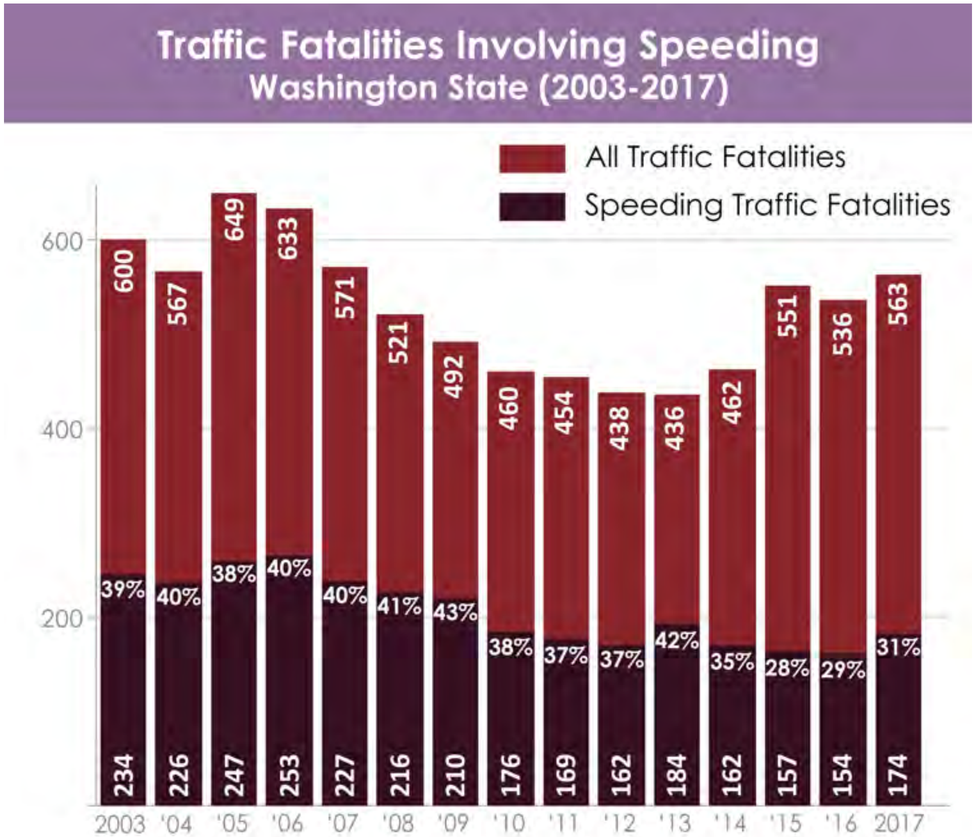
Posted speed is an important factor. Higher operating speed—whether or not the driver is actually exceeding the posted speed limit or driving too fast for conditions—increases exposure to negative outcomes. This is both in terms of the likelihood of being involved in a crash, as well as in terms of the severity of injuries sustained by those involved.

A number of national studies make it quite clear that focusing on speed management is absolutely essential to reducing the incidence



and severity of crashes and saving lives for all modes. Driving speed magnifies driver errors such as driving too close or driving when tired, distracted, or impaired, multiplying the chances of a crash. This is particularly the case when the speeds are not appropriate for context and operation of the roadway.

Most recently, in early 2019 the National Committee on Uniform Traffic Control Devices voted to require that pedestrian and bicyclist activity be considered when determining the speed limit on most urban and suburban streets. WSDOT has had this approach in its manuals for some time. Local jurisdictions should be encouraged to put this new national directive into practice.



From 2015–2017, pedestrians were 17.2% of traffic fatalities in WA State.
During this same time period, pedestrians were 17.3% of fatalities nationwide.

Speed management approaches support both the establishment of appropriate speed limits for the land use and users, and changes to roadways in locations where drivers are routinely exceeding the posted speed. That is, the topic concerns both speed and speeding.

WSDOT has convened a work group including state, local, and tribal partners to develop a speed management policy and guidelines focused on injury minimization. The policy will emphasize lower operating speeds on state routes, city streets, county roads, and tribal roads based on context and compatible with the needs of all types of users. Key factors to consider when setting operating speeds include high densities of older adults, transit users, youth, people who walk or ride bicycles—particularly those who are most reliant on active transportation and transit due to income or disability—and land use.

Once this work group develops a speed management policy, traffic safety professionals should pursue education at all jurisdictional levels and associated strategies in engineering, education, and enforcement.

Functional Harmony

Design road characteristics to be consistent with the needs of the expected road user groups and adjacent land-use context.

In environments where people are driving, walking, and rolling to businesses and residences, the road design needs to provide more frequent crossing opportunities, while the road characteristics should signal drivers to maintain lower speeds and expect crossings. One essential approach in this area is to improve integration of transportation in support of land use through collaborative planning across jurisdictions. Currently, Washington State's Growth Management Act does not require consideration of state transportation right-of-way. One example of the safety issues this creates is that local approval of a subdivision along a state highway sets up conflicts between through traffic and local-only traffic.

Functional harmony can also be improved by redesigning roads to reduce potential conflicts created by the different users on the system. For example, fewer access points on a state highway means fewer turns right or left from the system or onto the system, reducing conflicts with other users, although this must be balanced with the needs of those who need to cross the highway where it represents a barrier to a complete network.

The number of access points, speed limit, and travel lanes are all important variables when it comes to reducing the likelihood and severity of crashes. Functional classification is also tied to National Highway System (NHS) designation. The NHS includes the Interstate Highway System and other roads determined to be important to the nation's economy, defense, and mobility. NHS roads typically have higher functional classifications.

Prioritizing safety for Washington roads through our policies and guidance will include taking a closer look at the criteria for functional classification of roads and NHS status, and allowing for greater flexibility in the road characteristics on arterials and collectors based on land use and other factors described above under Speed Management and Separation.

NHS designation is important to WSDOT and local agencies because NHS roads are eligible for certain federal funding that cannot be used for non-NHS roads. In 2012, the Moving Ahead for Progress in the 21st Century (MAP-21) Act authorized by Congress resulted in designation of an additional 1,200 miles of NHS roads in Washington.

Predictability and Simplicity

Make it easier for everyone to use all roadways safely. People make fewer mistakes when they know what to expect, and when their decisions are simple.

The way we design and operate the roadway system helps structure user decisions. For example, intersections that feature protected left turn phases make it simpler for a driver to know when to turn. They can execute this maneuver without having to judge gaps in oncoming traffic, and without potentially failing to observe someone crossing the street in a crosswalk. Median islands allow people to cross a wide road in stages and check for traffic one direction at a time. Sidewalks and bicycle infrastructure that create a complete, connected network with well-designed and appropriately spaced crossing opportunities also contribute to this principle.

Forgiveness and Restrictiveness

Design and operate the roadway so that:

- *A simple mistake does not result in death or serious injury (forgiveness).*
- *The system prevents the user from making decisions that increase the likelihood for death or serious injury (restrictiveness).*

In this way, the road environment is influencing human behavior to reduce crash exposure, rather than increase it. Examples of approaches in this realm:

- Discourage passing where crash potential is high.
- Use median barriers to separate high-speed vehicular traffic on the interstate.
- Require greater passing distance around a vulnerable road user.
- Use curb bulbouts or a tighter turning radius to require a driver to turn more slowly, providing them with more time to see and respond to the presence of people walking in the crosswalk on the street into which they're turning.

This also includes the concept of "social forgivingness," a change in traffic culture to encourage treatment of other roadway users with courtesy and forgiveness for their mistakes since everyone makes them.

State Awareness

The ability of the user to assess their own capability to handle the driving, walking, and biking tasks.

Policy change, enforcement, and education can be used jointly to reduce or eliminate particular behaviors or poor decision-making by inexperienced, impaired, or distracted drivers. Since drivers of motor vehicles carry the majority of kinetic energy into any crash, their operational decisions and behaviors carry more consequences for others in a crash. Developing and distributing information on human factors and road-user interactions will contribute to this principle.

Examples of approaches include:

- Policy change to increase the consequences of driving in a way that endangers others.
- Changes to driver training.
- Education on the much higher odds of fatality for vulnerable users when hit by the driver of an SUV or other larger vehicle as compared with a smaller vehicle, the effects of impact speed on chance of fatality, and the importance of observing posted speed and reducing speeds based on conditions.
- Speed awareness courses, such as those offered in London as an alternative to paying a speeding fine and receiving penalty points for drivers caught driving at inappropriate speeds.
- Riding skills courses for bicyclists, motorcyclists, and users of rideable devices.

Other Considerations in the Safe Systems Approach

A Safe Systems approach broadens the discussion of traffic safety to include everyone, and helps identify structural and institutional contributors. Some of these factors are identified here, although the items below are by no means an exhaustive list.

The most vulnerable users. The likelihood of dying in a crash is influenced by the characteristics of the people involved in the crash. Older individuals walking or bicycling are more likely to die when a driver strikes them, and the mortality rate of vehicle occupants in a crash increases significantly with age (see page 153 for more information). The way we plan, design, operate, and maintain the road environment and vehicles should therefore take into account a context that includes older users of the system; for example, older people walking and using mobility devices require longer to cross a street. Given the large projected increase in the number of older residents in Washington, this is an important consideration for the state.

Roadway users with disabilities are also part of this vulnerable user group. In the first-ever nationwide study of its kind, Kraemer and Benton (2015) found that people using wheelchairs were 36% more likely to die when hit by a driver than the general pedestrian population. A number of their findings point to the need for both design and behavioral solutions. The data showed that in 76.4% of these crashes, the driver had made no apparent effort to avoid hitting the person using the wheelchair, and almost half of these fatal crashes occurred at intersections where someone might be expected to be crossing the road. Approximately 12.8% of Washington's population reportedly have a disability; the percentage varies by county, from 12% to over 29% and may not fully count those who have a temporary disability.

Equity. The need for infrastructure investment is particularly high in historically underserved neighborhoods, many of which were set aside in the past through government action for use by people of color or low-income households. These same areas have suffered from a lack of infrastructure investment over time. In these areas residents experience reduced private vehicle ownership, an increased reliance on walking, biking, and public transportation, and greater vulnerability across a number of indicators.

The discussions in the Transportation and Health Equity chapter (page 217) and in Appendix K: Safe Systems both expand on this important point.

Framing the problem for clearer understanding. Many times, the language we use, media coverage, and information from traffic crash reports combine to describe an individual crash as if it happens in isolation, rather than acknowledging the systemic issues that may be present. This limited perspective prevents communities from recognizing and addressing those issues. The usage discussion in the Traffic Safety Culture chapter (page 28) expands on this point.

Research shows that selective inclusion of some bits of information and not others results in blaming vulnerable road users in particular for crashes that occur for reasons beyond their control—factors that could be mitigated to prevent future loss of life. For example, a newspaper article noting that a person was not in a crosswalk does not provide enough information to fully describe possible contributing factors unless the article also points out, for example, that the nearest crosswalk is over a half-mile away. Crossing locations are a systemic issue that could be addressed through placement of appropriate crossing opportunities designed in alignment with the context of the speed and volume of drivers moving along that road, with markings and controls that take into consideration the driving speeds at which vulnerable road users are more likely to be killed.

To contribute to shifting our traffic safety culture, community leaders, law enforcement, and traffic safety professionals can provide the missing context necessary for a better understanding of possible contributing factors to the crash. When a driver hits someone, whether that is a person walking or biking or another driver, it is essential to identify patterns in contributing factors through evaluation, analysis, and diagnosis. Such analysis should include elements of the environment, the vehicle, and the user. The environment includes road design, land use context and local function of the facility, the presence or absence of individual features, and operating speed. The vehicle includes information on vehicle types, any failures in vehicle components, and vehicle movements. Information on the user includes their characteristics, actions, and behaviors. These three components help frame the real challenge, so we can collectively move toward solutions more likely to change crash outcomes.

Vehicle design. The effects of the driver's operating speed at impact are compounded by trends in vehicle design that can greatly increase the likelihood of death in the event of a crash. As both the National Transportation Safety Board (NTSB) and the Insurance Institute for Highway Safety (IIHS) reported in 2018, the rise in SUV popularity has led to an increased likelihood of death for those outside the vehicle. IIHS found that fatal crashes in which the driver of an SUV struck a pedestrian increased 81% from 2009 to 2016, more than any other type of vehicle, due to their higher carriage, larger body, blunt front end, and greater horsepower, which can encourage speeding. While pedestrian detection and automated braking technologies hold some promise for improved safety performance, older vehicles lacking such equipment will continue to be on the roads for years.

Given the starkness of these numbers, it becomes even more imperative that state and local jurisdictions use a multidisciplinary approach with every available tool for infrastructure planning, design, operations, and maintenance to structure driver decisions and actions, and that driver training and education address how vehicle characteristics affect safety performance for all roadway users so drivers understand and adjust for these factors.

The Safe Systems approach for infrastructure provides Washington State with the opportunity to address increases in fatalities and serious injuries by changing how the different disciplines work together. This includes how agencies plan, design, operate, and maintain the transportation system; the focus and intent of education and enforcement; and more. It is time for Washington to adopt the Safe Systems principles statewide in its policies, programs, projects, activities, and investments. When we do so, we will save lives, provide better stewardship of public resources, and improve the functioning of the transportation system for everyone using it. When we do so, everyone can arrive safely at their destination.

Strategies for Applying a Safe Systems Approach

In addition to the strategies below, other important contributions to a Safe Systems approach were previously identified as recommendations in the 2018 Pedestrian Safety Advisory Council report, the 2018 Cooper Jones Bicyclist Safety Advisory Report, and the 2018 STEP Pedestrian Safety Action Plan developed for WSDOT.

Strategies for Addressing Safe Systems (SYS) Fatalities and Serious Injuries		
Objective	Strategies	Implementation Areas
SYS.1. Apply the Safe Systems approach to prioritize proven countermeasures.	SYS.1.1 Complete infrastructure connectivity for pedestrians and bicyclists and make progress toward providing separation where needed based on crash exposure, crash history, and characteristics of the roadway and adjacent land use associated with higher levels of use. (P, NCHRP)	Engineering
	SYS.1.2 Develop and implement speed management policy, guidelines, and professional training focused on injury minimization. (R, WSDOT)	Education, Leadership
SYS.2. Address equity.	SYS.2.1 Conduct demographic analysis to identify communities of concern. (R, Lit)	Evaluation
	SYS.2.2 Increase investment in infrastructure in historically underserved areas where crash rates and severity are disproportionate to local and regional rates. (R, Lit)	Engineering, Evaluation
	SYS.2.3 Support and report on development of city and county road safety plans based in principles of systematic safety. (R, WSDOT)	Evaluation, Leadership
SYS.3. Improve data and analysis.	SYS.3.1 Develop and disseminate systematic safety data analyses by jurisdiction to provide context for crash rates, severity, contributing factors, and proven countermeasures. (R, WSDOT)	Evaluation
P: Proven R: Recommended U: Unknown