Hollywood, FL

June 13-14, 2024

2024 TRANSPORTATION SYMPOSIUM

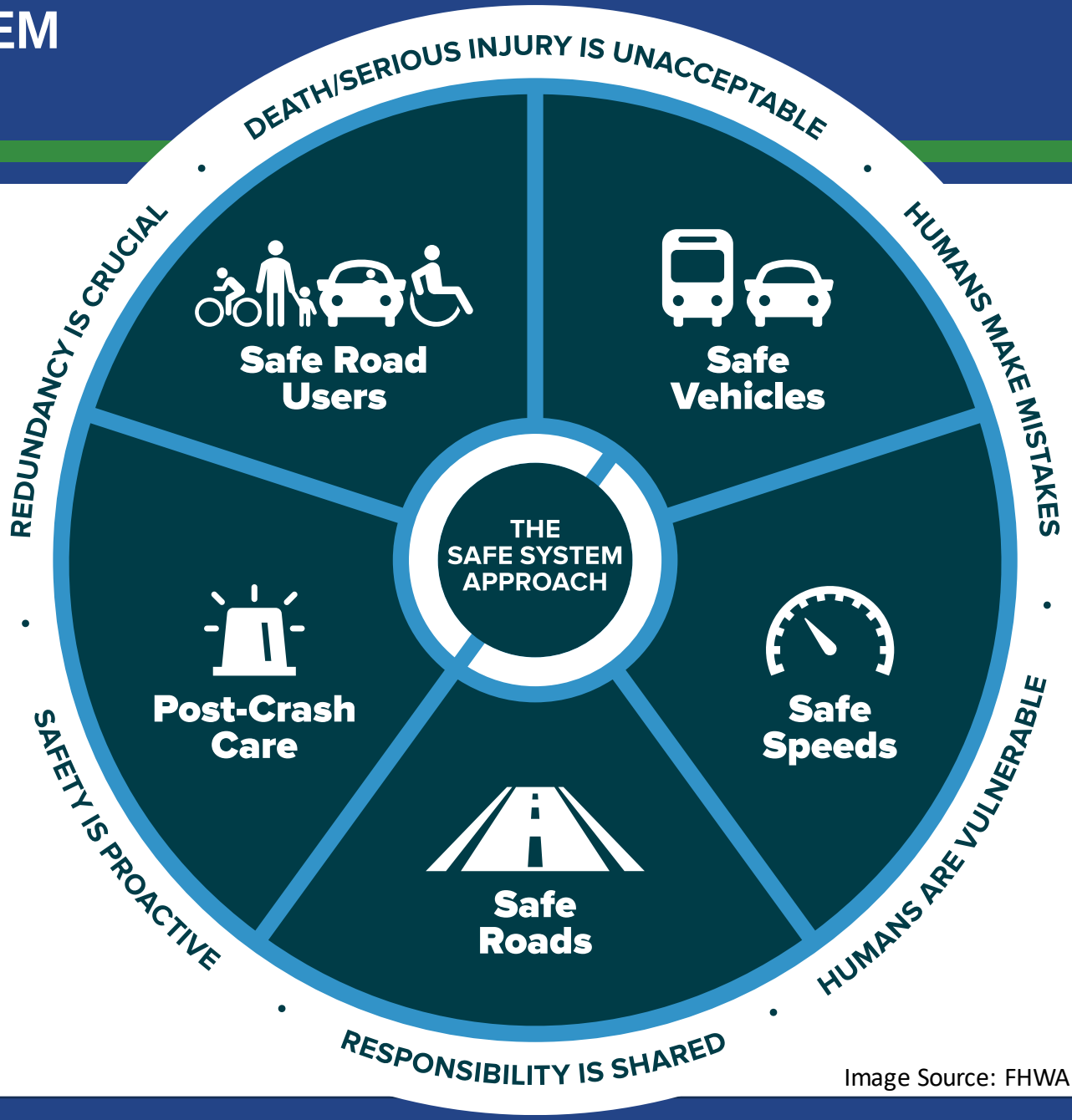
FHWA's Project-Level Safe System Alignment Framework and Tool

Elliott Moore

FHWA Resource Center

FDOT

THE SAFE SYSTEM APPROACH



Death/serious injury is unacceptable

Humans make mistakes

Humans are vulnerable

Responsibility is shared

Safety is proactive

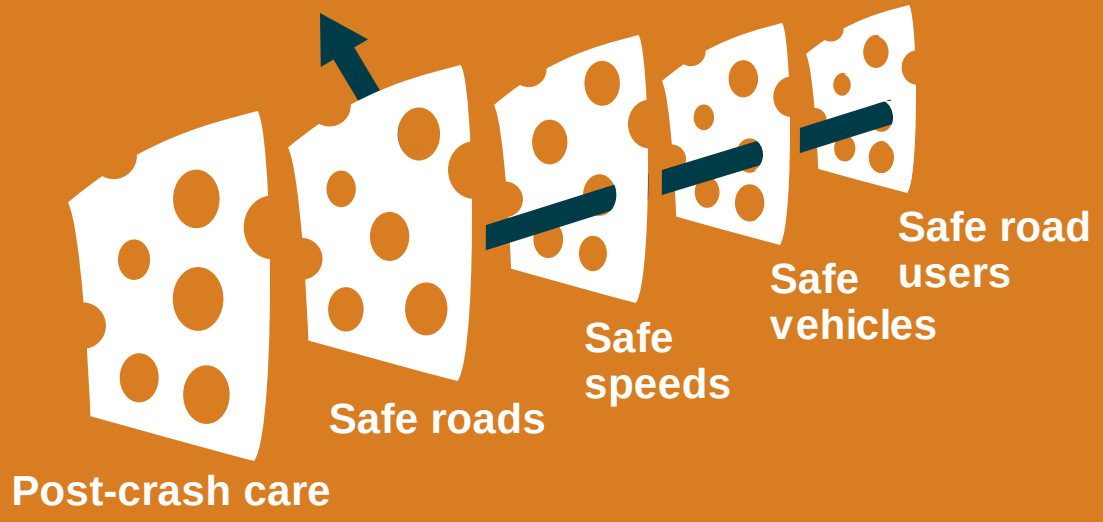
Redundancy is crucial

Image Source: FHWA

TRANSPORTATION SYMPOSIUM

Swiss Cheese Model

The “Swiss Cheese Model” of redundancy creates layers of protection



Death and serious injuries only happen when all layers fail

Adapted from James Reason’s model for analyzing accident causation
https://royalsocietypublishing.org/doi/10.1098/rstb.1990.0090

Image Source: FHWA

Top 3 Safe System "Takeaways"

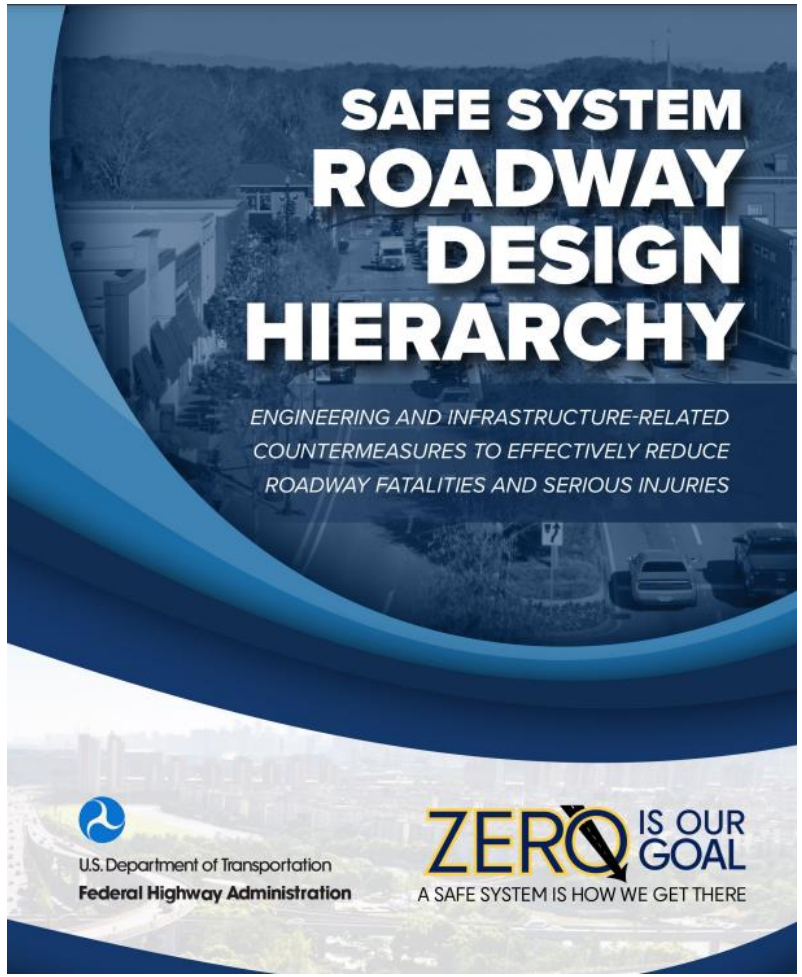
- The Safe System Approach is "Principles Based"
- Achieving a Safe System requires all five elements to be strengthened
- Safe Roads is a continuum, not an absolute

Applying a Safe System Approach

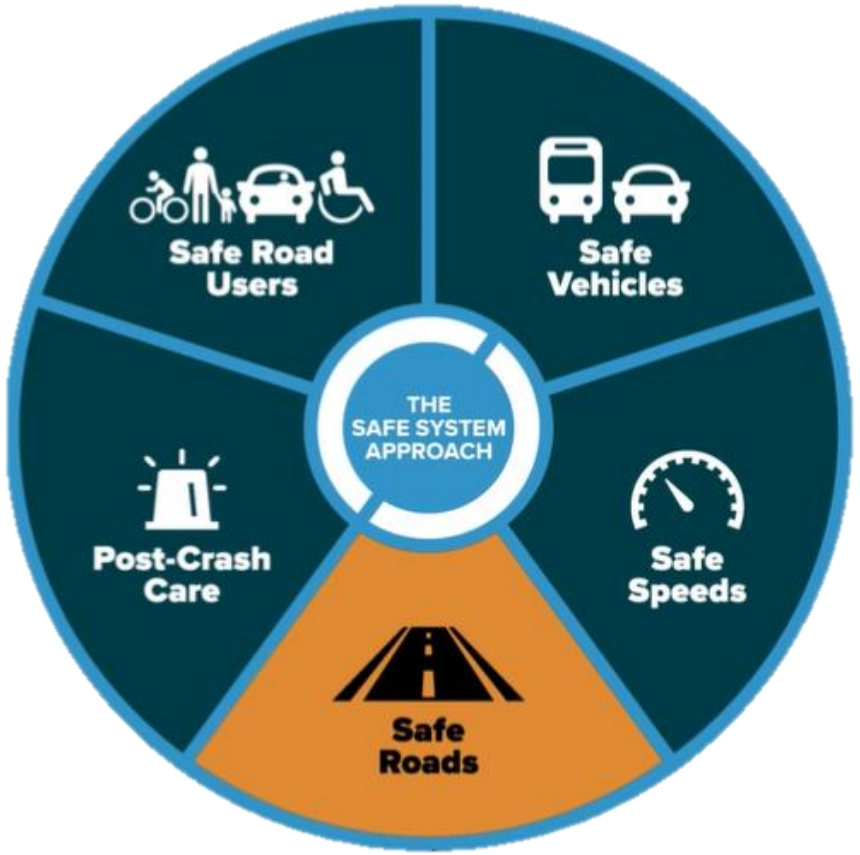
"… implementing the Safe System Approach"

What does that mean?

Advancing the Safe Roads Element in the SSA

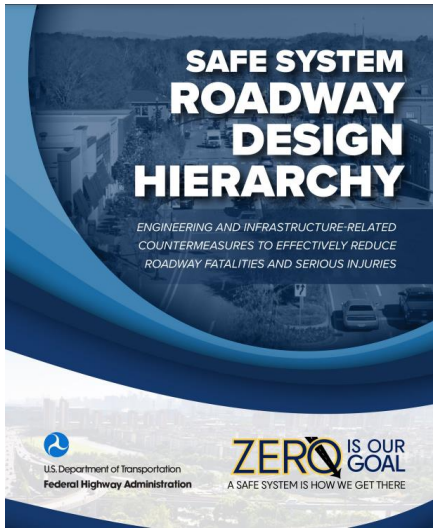


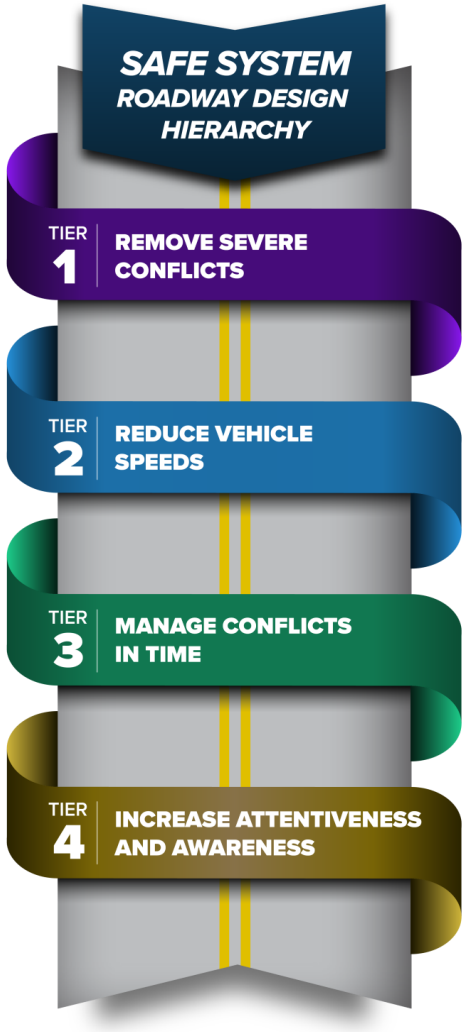
https://highways.dot.gov/sites/fhwa.dot.gov/files/2024-01/Safe_System_Roadway_Design_Hierarchy.pdf



Source: FHWA

Safe System Roadway Design Hierarchy





The Safe System Roadway Design Hierarchy is a tool that characterizes engineering and infrastructure-based countermeasures and strategies relative to their alignment with the Safe System Approach (SSA).

TRANSPORTATION SYMPOSIUM

Inspired by Occupational Safety

HIERARCHY OF CONTROLS

Eliminate
Physically remove the hazard

Substitute
Replace the hazard with option that lowers severity

Engineering Controls
Operate the system to reduce exposure

Administrative Controls
Education, legislation & policies to change behavior

Personal Protective Equipment
PPE, protective gear

The Safe System Roadway Design Hierarchy is emulated from the hierarchy of controls for workplace safety

TRANSPORTATION SYMPOSIUM

Adapted from National Institute for Occupational Safety and Health – https://www.cdc.gov/niosh/topics/hierarchy/default.html

Hierarchy of Street Safety Controls

MOST EFFECTIVE

LEAST EFFECTIVE

ELIMINATION

Physically Remove Traffic Hazards.
Pedestrian Streets, Offstreet Paths, Scramble Crossings, Dedicated Transitways, Automated Speed Limiters

SUBSTITUTION

Replace with Lesser Hazards.
Home Zones, Shared Streets, Neighborhood Greenways, Roundabouts, Automated Speed Enforcement

ENGINEERING CONTROLS

Isolate People from Traffic Conflicts.
Sidewalks, Protected Bikeways, Curbs, Bollards, Traffic Diverters, Pedestrian-Prioritized Signals, Speed Humps, Chicanes

ADMIN CONTROLS

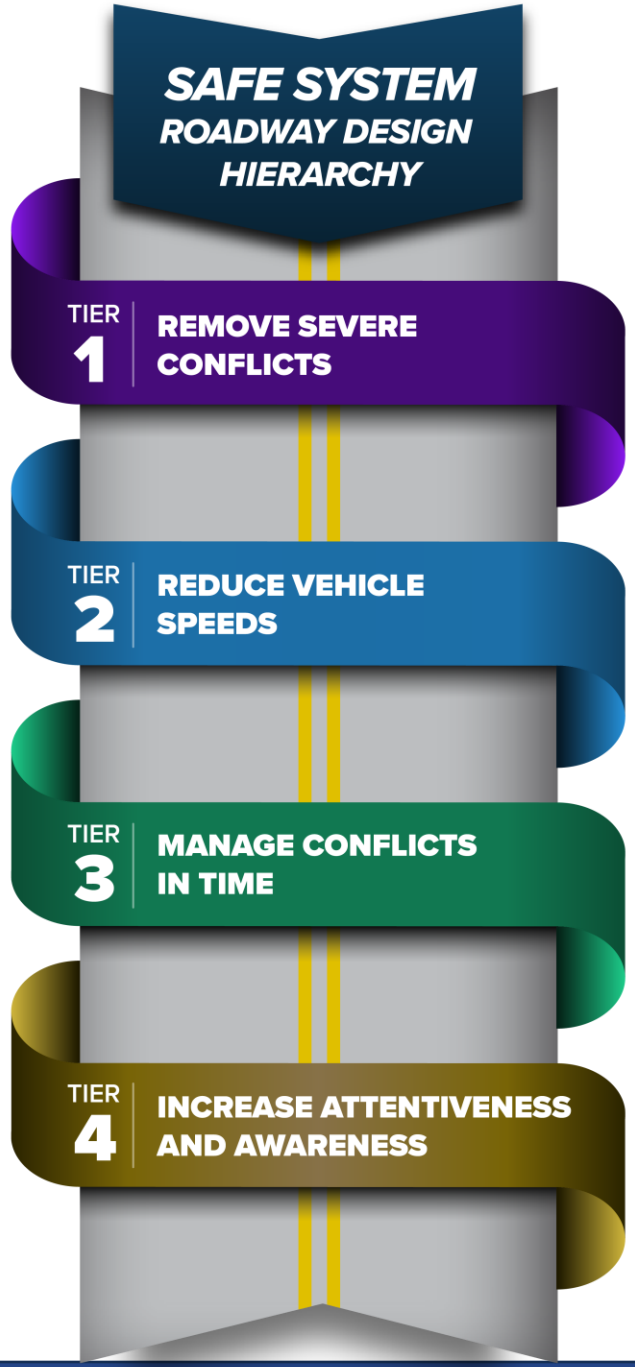
Change the Way People Travel.
Education Campaigns, Marked Crosswalks, Pedestrian Crossing Buttons, Sharrows, Permissive Signal Phases, Signage

PPE

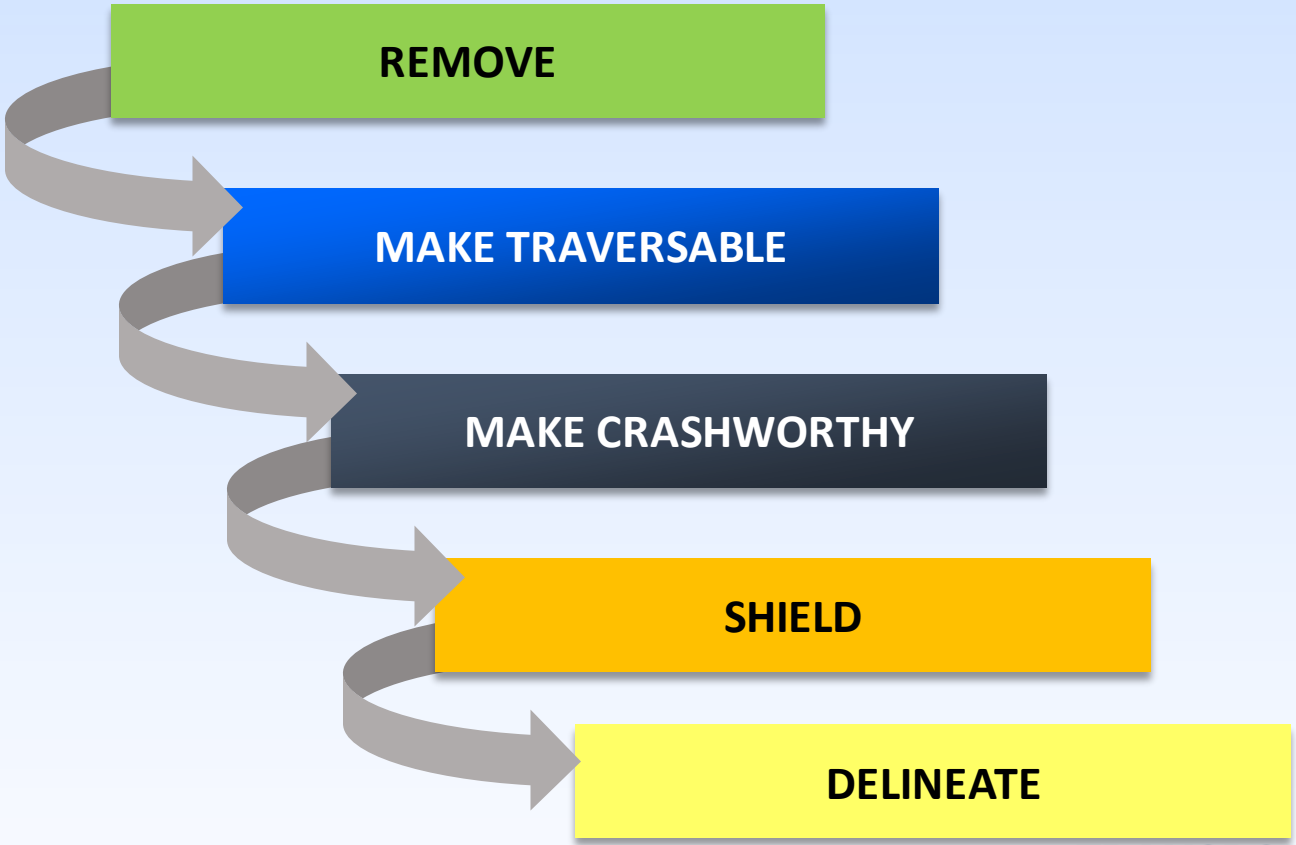
Safeguard with Personal Protective Equipment.
Reflective Vests, Pedestrian Crossing Flags, Bicycle Helmets, Seatbelts, Airbags

vision-zero-strategic-plan-120120.pdf (bellevuewa.gov)

What's Old is New



Hierarchy to address hazards within the roadside clear zone

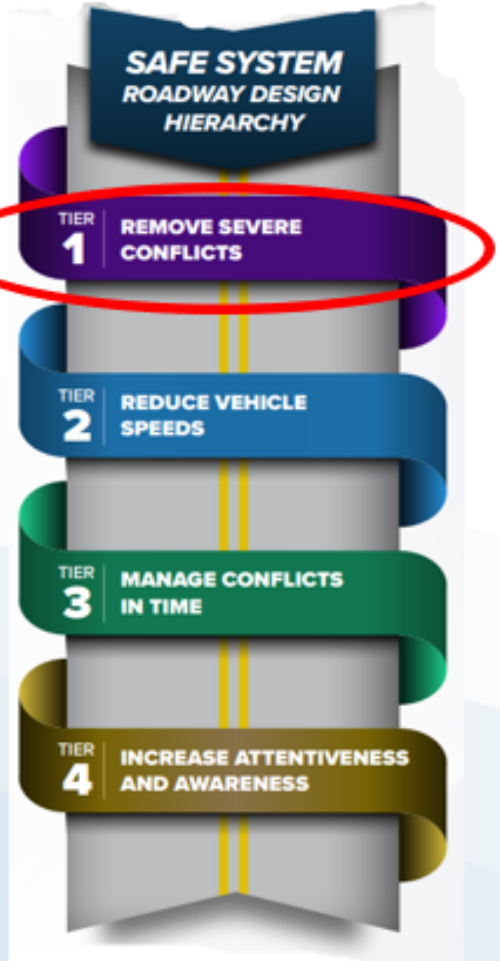


Derived from AASHTO Roadside Design Guide.

TRANSPORTATION SYMPOSIUM

Source: FHWA

TIER 1 REMOVE SEVERE CONFLICTS



TIER 1: REMOVE SEVERE CONFLICTS

Removing severe conflicts involves the elimination of specific high-risk conditions. This involves separating road users moving at different speeds or different directions in space to minimize conflicts with other road users. This tier includes strategies that remove conflicts such as intersection crossing conflicts, removing fixed objects along the roadside, or eliminating railway-highway crossings. Strategies in this tier may also include providing physical separation between motorized and non-motorized users to remove conflicts or providing varying degrees of buffered separation to reduce risk of collisions. These countermeasures support both the Safe Roads and Safe Road Users elements of the SSA.

- Physical separation of users
- Removal of intersection crossing conflicts
- Removing roadside objects
- Eliminating high-risk conditions

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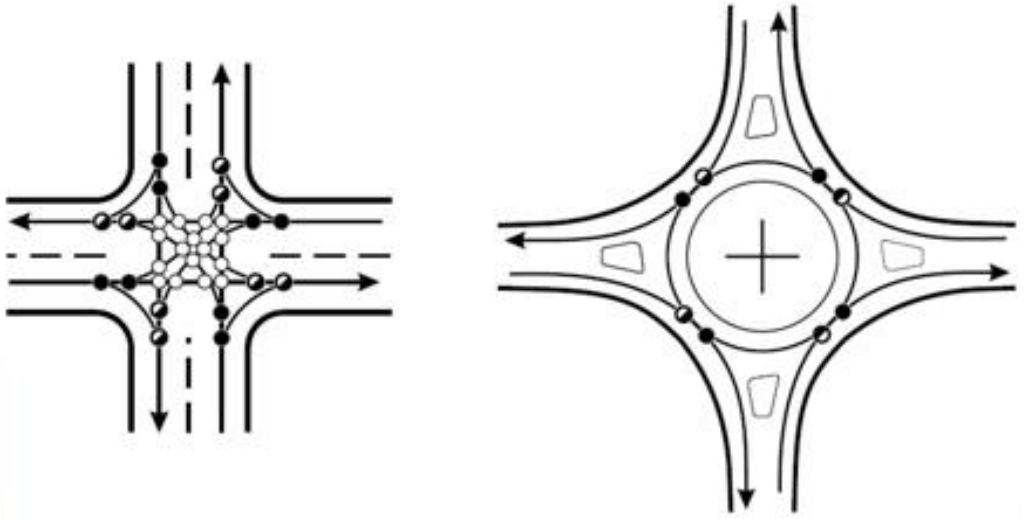
Federal Highway Administration

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

REMOVE SEVERE CONFLICTS

ROUNDABOUTS

Roundabouts eliminate the severe crossing conflicts



Diverging	8
Merging	8
Crossing	16
	32

Diverging	4
Merging	4
Crossing	0
	8

Image derived from: https://dublinohiousa.gov/roundabouts

TIER 2 REDUCE VEHICLE SPEEDS

TIER 2: REDUCE VEHICLE SPEEDS

Implementing design features and speed management strategies to reduce vehicle speeds effectively reduces the kinetic energy involved in a crash should it occur. States and local jurisdictions should set appropriate speed limits to reduce the significant risks drivers impose on others—especially vulnerable road users—and on themselves. To achieve desired speeds, agencies often implement other speed management strategies concurrently with setting speed limits, such as self-enforcing roadways, traffic calming measures, and speed safety cameras. Self-enforcing roads involve the use of road and roadside design elements, such as lane narrowing, intersection channelization, and horizontal and vertical deflection, to elicit lower travel speeds of motor vehicles along the roadway. This also includes features for pedestrians and bicyclists, such as median islands, raised crosswalks, and buffered bicycle lanes. These countermeasures support the Safe Roads, Safe Speeds, and Safe Road Users elements of the SSA.


Example of raised pedestrian crosswalk

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SELF ENFORCING ROADS

A self-enforcing (or self-explaining) roadway is planned, designed, and operated to offer contextual encouragement for motorists to drive at safer speeds in alignment with the roadway purpose and adjacent land uses using concepts such as:

- Using combinations of roadway features, geometric design, signs and pavement markings to encourage safe driver behavior
- Using an inferred design speed approach
- Setting rational speed limits
- Applying a speed feedback loop process

Self-Enforcing Roads

Source: Dan Hartman, City of Golden, CO – https://highways.dot.gov/safety/speed-management/noteworthy-practice-booklet-speed-management/case-study-2-noteworthy-speed.

TIER 3 MANAGE CONFLICTS IN TIME

TIER 3: MANAGE CONFLICTS IN TIME

Managing conflicts in time assumes that users will need to occupy the same physical space on the roadway but creates a safer environment by separating the users in time using traffic control devices, such as traffic signals or hybrid beacons, to minimize vehicle conflicts with vulnerable road users. Providing discrete and alternating opportunities for users to navigate the roadway environment is not only a safety strategy, but also one that relates to user comfort and convenience, especially for non-motorized users. These solutions support the Safe Roads, Safe Speeds, and Safe Road Users elements of the Safe System Approach.

Proven Safety Countermeasures

- Leading Pedestrian Interval
- Pedestrian Hybrid Beacons
- Yellow Change Intervals

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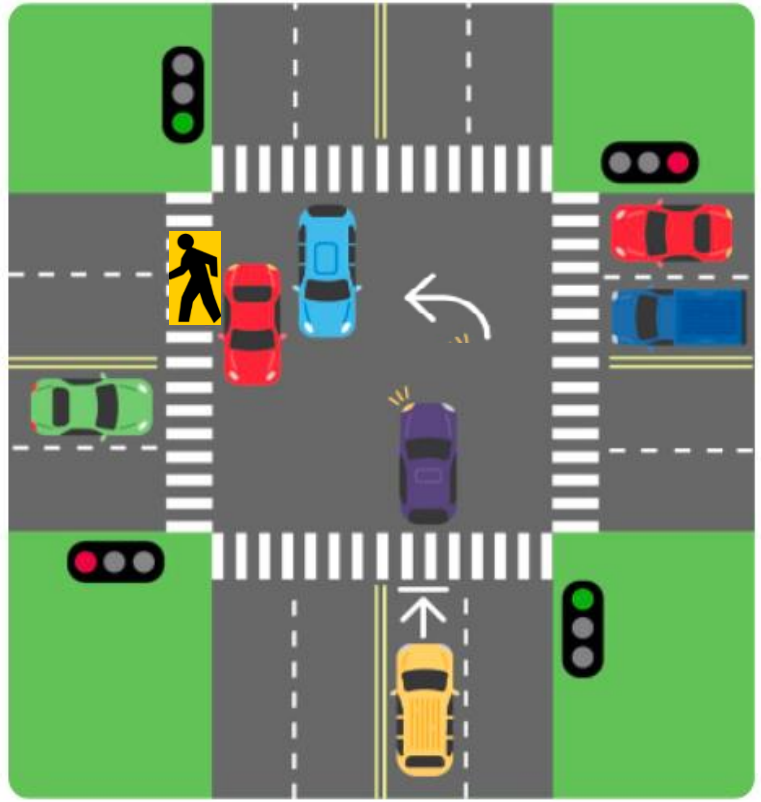
Protected Left Turn Signal Phasing

"Permissive" left-turning vehicular traffic is a concerning risk that pedestrians and cyclists face at many signalized intersections

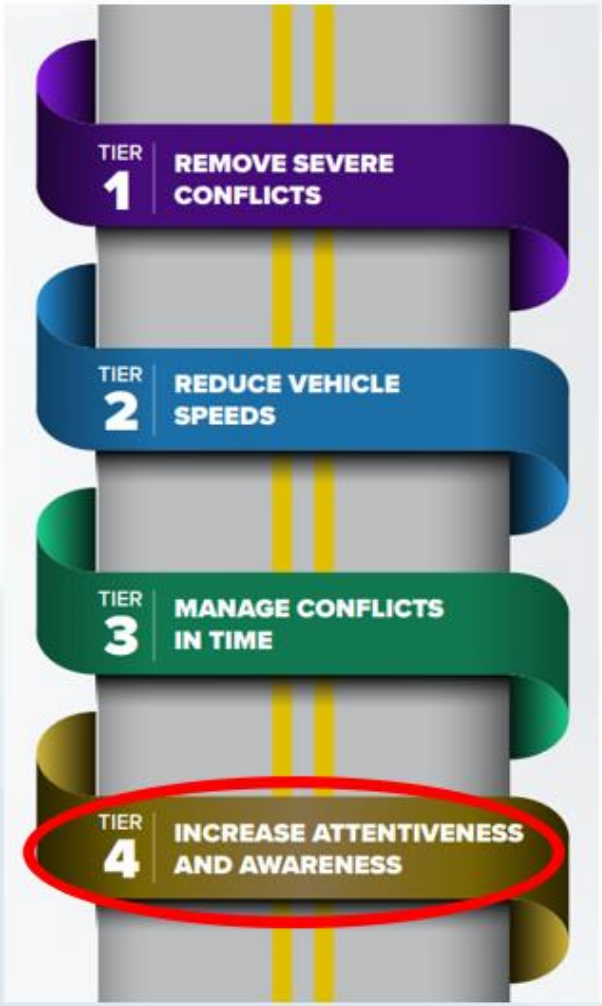
TIER 3 | MANAGE CONFLICTS IN TIME

Consider:

- Protected only left turn signal phasing; or
- Flashing Yellow Arrow to omit permissive movement when there is a pedestrian call



TIER 4 | INCREASE ATTENTIVENESS AND AWARENESS

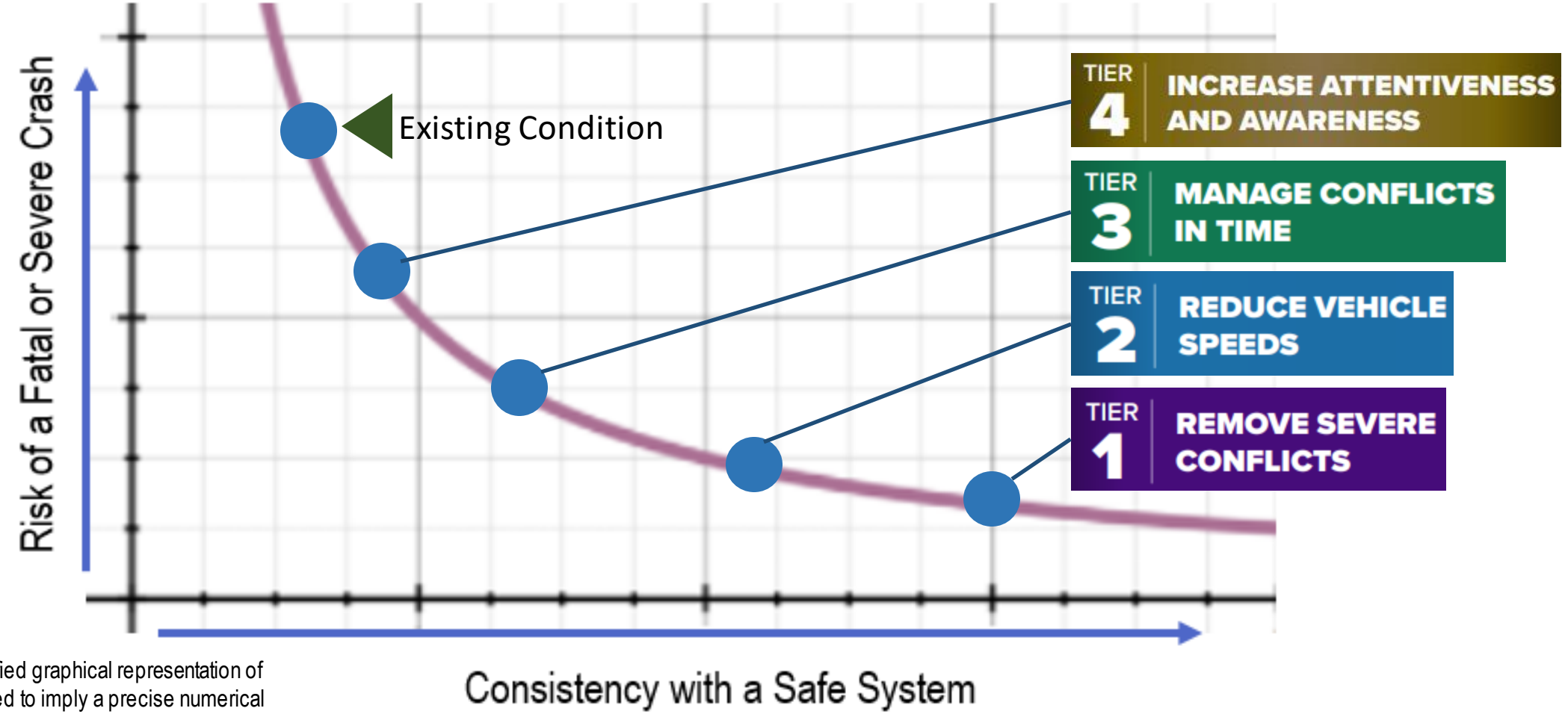


Example of transverse rumble strips providing a tactile and audible warning to alert drivers of an upcoming intersection approach

TIER 4: INCREASE ATTENTIVENESS AND AWARENESS

Increasing attentiveness and awareness involves alerting roadway users to certain types of conflicts so that appropriate action can be taken consistent with the Safe System Approach principle that responsibility is shared. Examples that fall into this category include crossing visibility enhancements, backplates with retroreflective borders, and rumble strips/stripes. These countermeasures support the Safe Roads, Safe Speeds, and Safe Road Users elements of the Safe System Approach.

“Safe Roads” is a Continuum – Not an Absolute



Note: This figure is a simplified graphical representation of a concept and is not intended to imply a precise numerical relationship. The lack of units on this graph is intentional.

Applying the Hierarchy to Implement Complete Streets

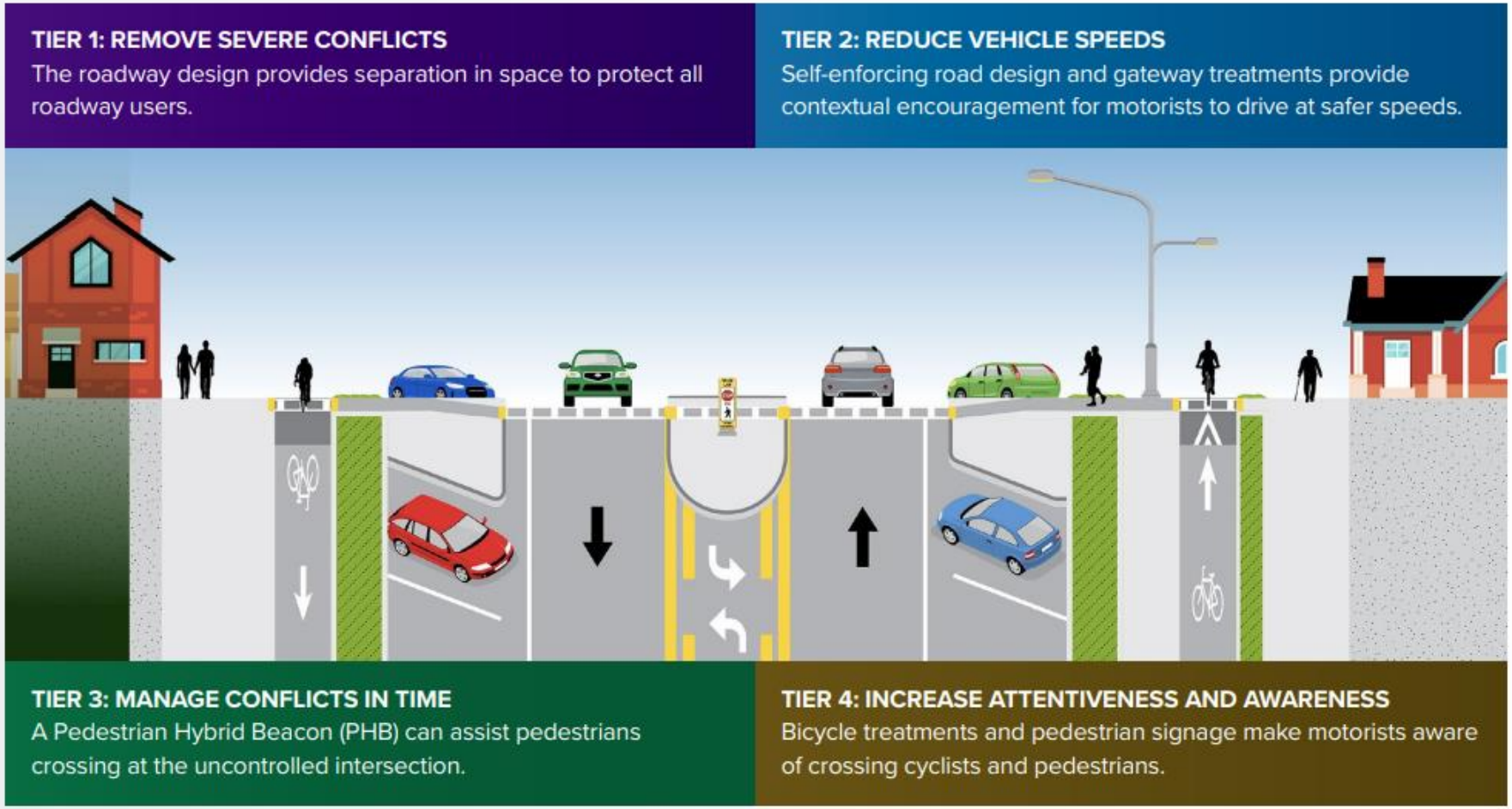


Image source: Complete Streets Transformations, FHWA: Complete Streets Transformations (dot.gov).

Complete Streets implementation may apply the Safe System Design Hierarchy to identify and prioritize safety enhancements.

Safe System PROJECT-BASED Alignment Framework

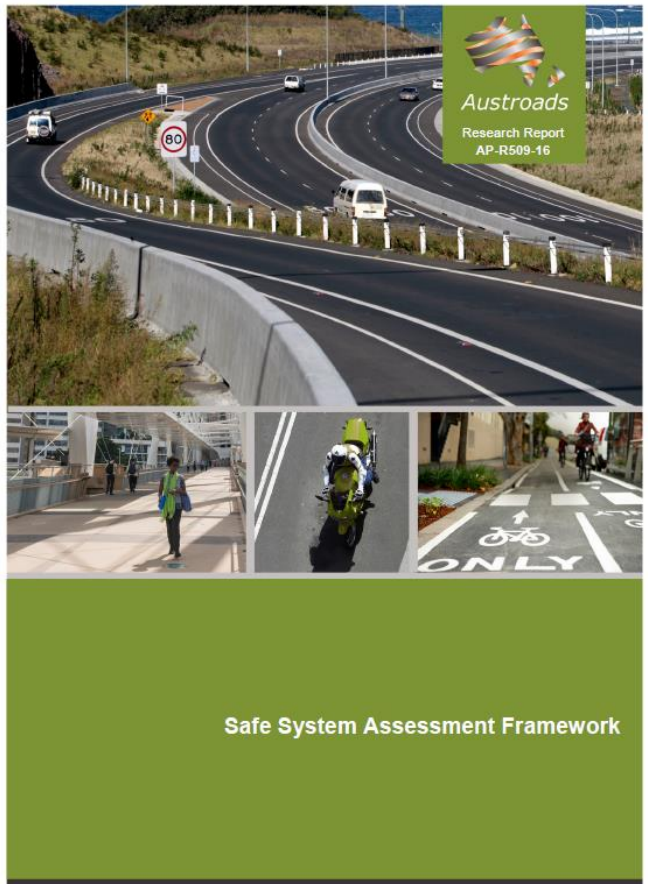
Practitioners can use the Safe System Project-Based Alignment Framework to assess roadway locations and potential improvements through a Safe System lens. The criteria and use of this framework lends itself to infrastructure projects and comparison among alternatives for specific locations, including those found in the Safe System Roadway Design Hierarchy. The Safe System Project-Based Alignment Framework provides practitioners a means of contrasting improvements relative to one another through a quantitative scoring matrix and qualitative safety prompts. The scoring matrix captures Safe Roads and Safe Speeds SSA elements using Crash Exposure, Crash Likelihood, and Crash Severity for both vulnerable road users and motor vehicle occupants. The safety prompts capture the remaining three SSA Elements (Safe Road Users, Safe Vehicles, Post-Crash Care), as well as considerations for integrating equity.

How to Use the Framework:

- **ASSESS EXISTING CONDITIONS** and supplement Road Safety Audits through a Safe System lens using quantitative (crash exposure, likelihood, severity) and qualitative (safety prompts) evaluations of the site.
- **EVALUATE AND COMPARE PROJECT ALTERNATIVES** that can help improve Safe System alignment (e.g., eliminating risks, reducing exposure, etc.) using the Safe System Roadway Design Hierarchy to determine the best (i.e., cost/benefit) solution for the site.

Safe System Alignment Frameworks (dot.gov)

Background – International Perspectives



"… designed to help road agencies methodically consider Safe System objectives in road infrastructure projects."

Table 4.2: Safe System assessment framework for infrastructure projects

	Run-off-road	Head-on	Intersection	Other	Pedestrian	Cyclist	Motorcyclist
Exposure	AADT; length of road segment	AADT; length of road segment	AADT for each approach; intersection size	AADT; length of road segment	AADT; pedestrian numbers; crossing width; length of road segment	AADT; cyclist numbers; pedestrians	AADT; motorcycle numbers; length of road segment
Likelihood	Speed; geometry; shoulders; barriers; hazard offset; guidance and delineation	Geometry; separation; guidance and delineation; speed	Type of control; speed; design, visibility; conflict points	Speed; sight distance; number of lanes; surface friction	Design of facilities; separation; number of conflicting directions; speed	Design of facilities; separation; speed	Design of facilities; separation; speed
Severity	Speed; roadside features and design (e.g. flexible barriers)	Speed	Impact angles; speed	Speed	Speed	Speed	Speed

https://austroads.com.au/latest-news/safe-system-assessment-framework

Safe System Project-Based Alignment Framework
For Project Locations

FHWA-SA-2023-009

U.S. Department of Transportation
Federal Highway Administration

Overview

The Safe System Project-Based Alignment Framework (Project-Based Framework) was developed to assess roadway locations and potential improvements through a Safe System Approach (SSA) lens. The criteria and use of this framework lends itself to infrastructure projects and comparison among alternatives for specific locations. The Project-Based Framework provides practitioners a means of contrasting those improvements relative to one another through a scoring matrix, which focuses on Exposure, Likelihood and Severity for both vulnerable road users and motor vehicle occupants. The Project-based Framework also includes prompts that are based on the other SSA Elements (Safe Road Users, Safe Vehicles, Post-Crash Care), as well as Equity. This approach was developed with the SSA Principles in mind, and to be consistent with the Safe System Roadway Design Hierarchy.

This tool provides comparative analysis based on a series of data inputs and risk evaluations. It is an easy-to-use spreadsheet tool that uses inputs and information typically available at the project planning stage, available via online mapping or roadway inventory database systems, or by field review of a given location.

How to Use the Framework

Users first complete the spreadsheet to evaluate project location existing conditions. Inputs can be collected from Google Street View or similar sources. This can also be used supplement Road Safety Audits through a Safe System lens using quantitative (exposure, likelihood, severity) and qualitative (prompts) evaluations of the site.

Once a score is derived for existing conditions, the user can complete the spreadsheet for each of the proposed project alternatives. The final score is relative, meaning lower scores are closer to alignment with the Safe System Approach than higher scores. This score can be used to compare proposed solutions to the existing conditions, as well as to evaluate and compare proposed alternatives.

Tabs

Project-Based Alignment Framework

Project-Based Alignment Framework Factors

Safe Speeds, Safe Roadways *(Quantitative)*

- Crash Exposure
- Crash Likelihood
- Crash Severity

Safe Users, Safe Vehicles, Post-Crash Care *(Qualitative)*

- Prompts and Questionnaires

Source: FHWA.

Managing Expectations

Merriam-Webster

framework noun

frame·work ˈfrām-ˌwərk

Synonyms of *framework* ›

1 **a** : a basic conceptional structure (as of ideas)

> the *framework* of the U.S. Constitution
>
> These influences threaten the very *framework* of our society.

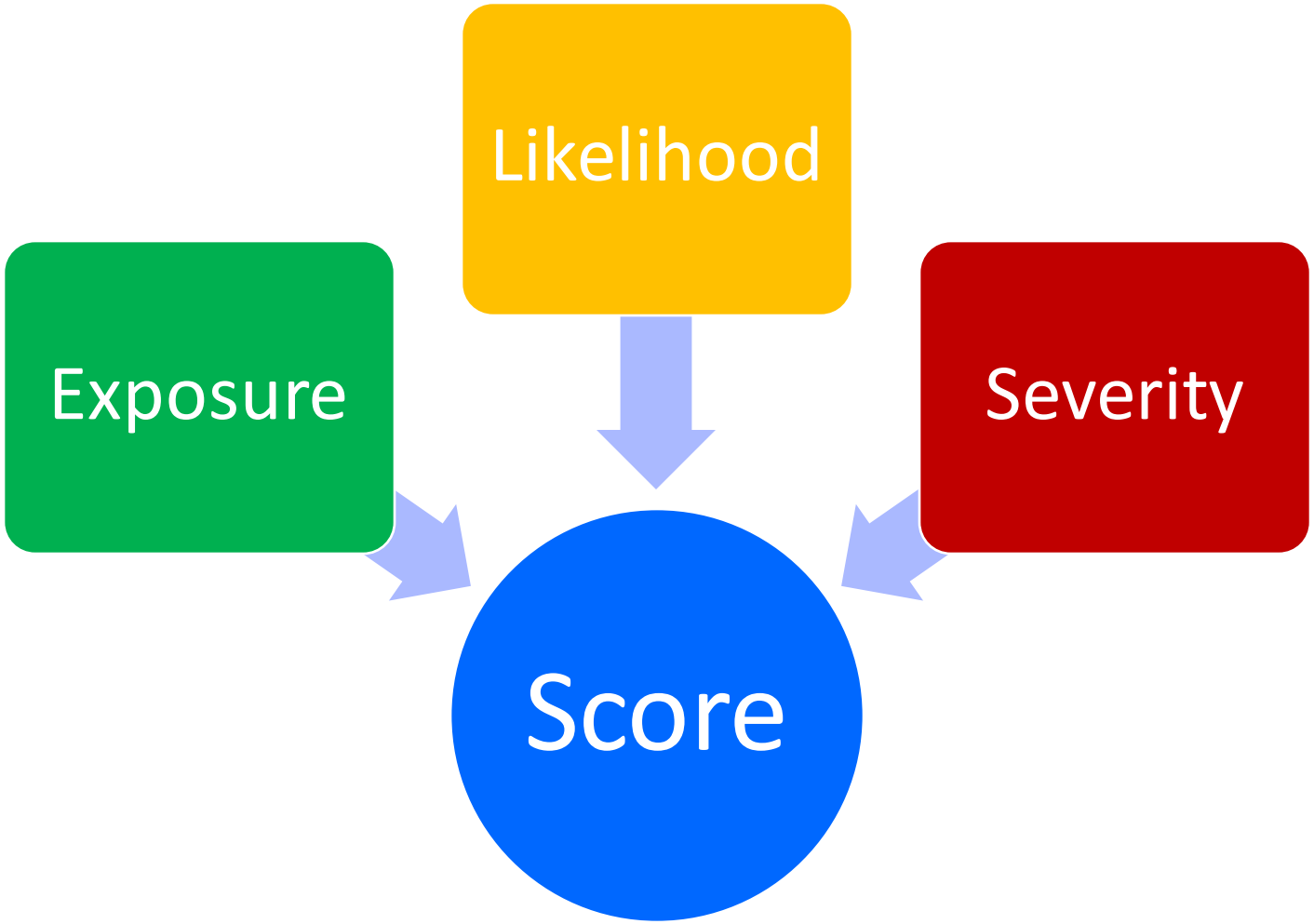
b : a skeletal, openwork, or structural frame

> An iron *framework* surrounds the sculpture.

Flexible structure ≠ Rigid adherence to defaults

Source: https://www.merriam-webster.com/dictionary/framework

Project-Based Alignment Framework



Exposure

Source: FHWA.

The volume and/or length (distance) various users are using a facility and could be involved in a potential crash

Project-Based Alignment Framework: Exposure Scoring Matrix

	A	B
4	Vulnerable Road Users	
5	**Factor: Vulnerable Users Present (users per day)**	
6	**Thresholds**	**Values**
7	Less than 10	1
8	10 - 25	4
9	25 - 50	6
10	50 - 100	8
11	Greater than 100	10
12	**User Input VRU Count**	
13	**Score**	**0**
14	**Factor: Crossing Distance (Max Number of Lanes)**	
15	**Thresholds**	**Values**
16	One Lane	1
17	Two Lanes	4
18	Three Lanes	6
19	Four Lanes	8
20	More than Four Lanes	10
21	**User Input Distance**	
22	**Score**	**0**
23	**Exposure Score: Vulnerable Road Users Subtotal**	***0***

	A	B
25	Motor Vehicles	
26	**Factor: Motor Vehicle Volumes (AADT)**	
27	**Thresholds**	**Values**
28	Less than 1,000	1
29	1,000 - 5,000	4
30	5,000 - 10,0000	6
31	10,000 - 15,000	8
32	Greater 15,000	10
33	**User Input AADT**	
34	**Score**	**0**
35	**Factor: Roadway Width (feet)**	
36	**Thresholds**	**Values**
37	Less than 30	1
38	30 - 35	4
39	36 - 41	6
40	42 - 47	8
41	48 or more	10
42	**User Input Width**	
43	**Score**	**0**
44	**Exposure Score: Motor Vehicles Subtotal**	***0***

Likelihood

Source: FHWA.

Elements and/or risks that impact the probability of a crash taking place by influencing the opportunity for conflict and/or user error rates

Risk Factors – Motor Vehicles

- Lighting Conditions
- Fixed Objects
- Right Turn on Red Conditions
- Permissive Left Turns
- Obstructed Sight Distance
- Topography (grade)
- Roadside Recovery Area
- Roadside Drop Off
- Rumble Strips
- Right Turn Lane Channelization
- Driveways
- Separation of Opposing Traffic Movement
- Crossing Conflicts
- Intersection Skew
- Road Curvature

The Framework Tool allows users to enter additional risk factors

Risk Factors – Pedestrians & Bicycles

- Space Separation
- Crosswalk Markings
- Right Turn on Red Conditions
- Permissive Left Turns
- Bicycle Boxes
- Separation in Time
- Pedestrian Signal Phasing
- Bicycle Signals
- Lighting
- Obstructed Sight Distance
- Driveways
- Topography (grade)
- Free Flow Right Turns
- Intersection Skew
- Road Curvature

The Framework Tool allows users to enter additional risk factors

Severity

Factors that impact the probability of a serious or fatal injury in the event of a crash

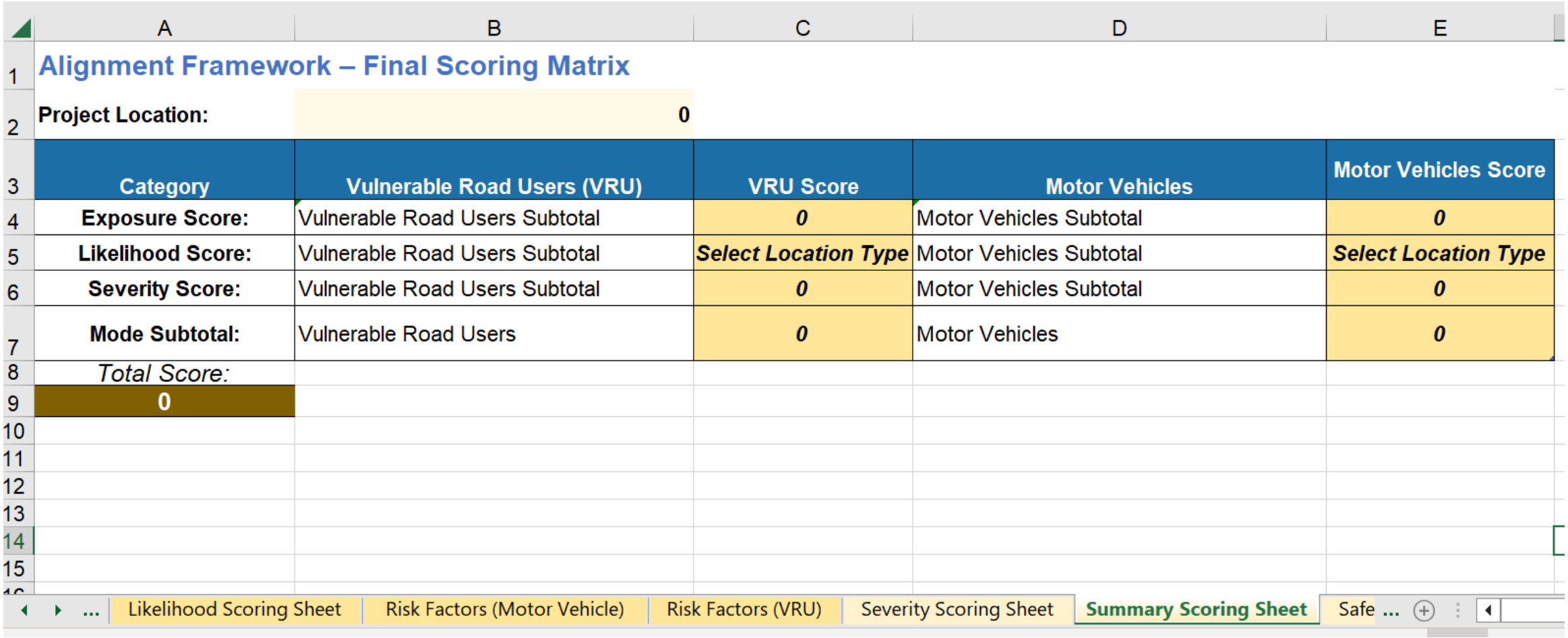
Source: FHWA.

Severity Scoring

	A	B
1	**Alignment Framework – Severity Scoring Matrix**	
2	Project Location:	0
3	*Category: Severity*	
4	Vulnerable Road Users	
5	**Risk Factor: Operating Speed (mph) or Speed Limit +7 mph**	
6	**Thresholds**	**Values**
7	0 - 20	1
8	21 - 25	5
9	26 - 30	10
10	31 - 35	15
11	Over 35	20
12	**User Input Speed**	
13	**Score**	**0**
14	**For proposed conditions only: Do proposed improvements address factors impacting speed**	
15	**Vulnerable Road Users Subtotal**	***0***
16	**Comments and Assumptions (Discuss these improvements. Be sure to consider if these changes create new potential for severe conflict or speeding.) (Optional)**	

	A	B
17	Motor Vehicles	
18	**Risk Factor: Operating Speed (mph) or Speed Limit +7 mph**	
19	**Thresholds**	**Values**
20	0 - 25	1
21	26 - 30	3
22	31 - 35	6
23	36 - 40	9
24	41 - 45	12
25	46 - 50	15
26	51 - 55	18
27	Greater than 55	20
28	**User Input Speed**	
29	**Score**	**0**
30	**For proposed conditions only: Do proposed improvements address factors impacting speed**	
31	**Motor Vehicles Subtotal**	***0***
32	**Comments and Assumptions (Discuss these improvements. Be sure to consider if these changes create new potential for severe conflict or speeding.) (Optional)**	

Alignment Scoring Matrix



	A	B	C	D	E
1	**Alignment Framework – Final Scoring Matrix**				
2	**Project Location:**	**0**			
3	**Category**	**Vulnerable Road Users (VRU)**	**VRU Score**	**Motor Vehicles**	**Motor Vehicles Score**
4	**Exposure Score:**	Vulnerable Road Users Subtotal	***0***	Motor Vehicles Subtotal	***0***
5	**Likelihood Score:**	Vulnerable Road Users Subtotal	***Select Location Type***	Motor Vehicles Subtotal	***Select Location Type***
6	**Severity Score:**	Vulnerable Road Users Subtotal	***0***	Motor Vehicles Subtotal	***0***
7	**Mode Subtotal:**	Vulnerable Road Users	***0***	Motor Vehicles	***0***
8	*Total Score:*				
9	**0**				
10					
11					
12					
13					
14					
15					

... | Likelihood Scoring Sheet | Risk Factors (Motor Vehicle) | Risk Factors (VRU) | Severity Scoring Sheet | **Summary Scoring Sheet** | Safe ...

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Reality Check

- What do the scoring numbers mean?
  - The scoring values are unitless and meant for comparison purposes only

- For what purposes should I use this tool?
  - Comparisons of current conditions to proposed improvements
  - Comparisons of options and alternatives

Application to Support Road Safety Audits

Application of Safe System Framework

Step 4 – Perform Field Reviews
- Assess Framework Risk Factors

Step 5 – Analyze and Report on Findings
- Quantitative Scores for Vulnerable Road Users and Motor Vehicles

Step 6 – Present Findings to Owner
- Quantitative Comparison of Existing Conditions to RSA Suggestions

Road Safety Audits (RSA) | FHWA (dot.gov)

Other Safe System Elements

Alignment Framework – Additional Safe System Prompts

Project Location: 0

Safe System Elements	Prompts
Road User	1. Are there design elements and built environment that impact user behaviors? Are there factors that might influence this? 2. What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours)? What is the likelihood of driver fatigue? Can enforcement of these issues be conducted safely? 3. Are there considerations for bicycle, micro-mobility, moped, scooter and motorcycle user separation and visibility. 4. Are there special user groups in the community that require additional consideration and treatments? For example, school access routes; zero-car or low income households; homelessness and substance abuse in area; aging population; physical and mental health facilities; etc?

Other Safe System Elements

Safe System Elements	Prompts
Vehicle	1. What level of alignment is there with the ideal of safer vehicles? 2. Has vehicle breakdown been catered for? 3. Are there commercial vehicle enforcement possibilities in the area (e.g., shoulders, pull-offs, other private/commercial locations)? Can enforcement of these issues be conducted safely? 4. Are there considerations for heavy vehicle speeding issues; turning radii (driveways and intersections), acceleration and deceleration lane/ramp design and TCD for speed; roadside delivery/parking locations, required weaving or left turns from driveway/intersection access points (e.g., downstream U-turns or routing; traffic gaps at crossovers; one or two stage left turns)?
5	

	Safe System Elements	Prompts
6	**Post-crash care**	1. Are there issues that might influence safe and efficient post-crash care in the event of a severe injury (e.g. congestion, access stopping space)? What are the expected response times the location? 2. Do emergency and medical services operate as efficiently and rapidly as possible? 3. Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there reliable information available via radio, VMS etc. 4. Are incident management plans developed and available for the corridor/route? 5. Is the location covered by traffic control technology (signal and freeway ATM Systems) to manage incidents?
7	**Equity**	1. Does the alternative consider all users? 2. Is access for vulnerable users impacted? If so, how? 3. Has the underrepresented community been involved in the project?

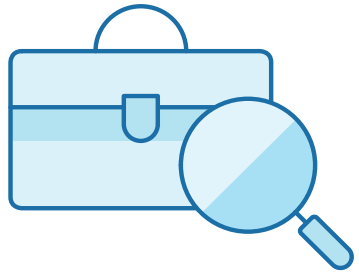
Safety Analysis Toolbox

Crash-Based Tools (HSM)

- Regression-based models
- Relies on past crash data
- Context-based (rural/urban, functional class, segment/ intersection, etc.)
- Local calibration is important

SSA Alignment Tool

- Does not rely on crash data
- RSA-style, prompt-based series of questions
- Framework allows for adjustments based on local conditions and priorities
- Results characterized in numeric terms intended for relative comparison



Safe System Intersection (SSI) Analytical Method

- Does not rely on crash data
- Uses kinetic energy management model (KEMM)
- Principles-based, not crash-based
- Inputs, methodology are objective, numeric

Safe System POLICY-BASED Alignment Framework

Practitioners can use the Safe System Policy-Based Alignment Framework to help agencies assess policies, plans, processes, programs, and documents in a holistic manner through a Safe System lens. The Policy-Based Alignment Framework includes seven criteria:

1. Death and Serious Injuries are Unacceptable.
2. Humans Make Mistakes.
3. Humans are Vulnerable.
4. Responsibility is Shared.
5. Safety is Proactive.
6. Redundancy is Crucial.
7. Equity.

Agencies assess the level of Safe System alignment through a series of questions for each criterion.

WHERE TO START (examples)**:**

- Highway Safety Improvement Program Manuals
- State, Regional, and Local Safety Plans
- Highway Safety Analysis Procedures
- Road Safety Audit Guides
- Roadway design manual
- Speed management policy

The Safe System Policy-Based Alignment Framework was developed to be flexible and can be completed individually or as a group. The framework is most beneficial when conducted by an assessment team consisting of as many stakeholder representatives as possible, specifically those that are familiar with or have reviewed the policy under consideration. After completing the framework individually, a facilitator with indepth understanding of the SSA should lead the assessment team to review the results together. The team should examine and discuss the resulting scores for each of the criteria. These scores and discussion will provide an indication of areas of strength, as well as potential areas for improvement.

Contact Us

Elliott Moore, PE
Senior Safety Engineer
FHWA Resource Center
elliott.moore@dot.gov

Mark Doctor, PE
Senior Safety & Design Engineer
FHWA Resource Center
mark.doctor@dot.gov

THE SAFE SYSTEM APPROACH

Zero is our goal. A Safe System is how we get there.