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Research + Consulting

Proven & Promising Strategies to Improve Pedestrian Safety

Rebecca L. Sanders, PhD, RSP_{2B}

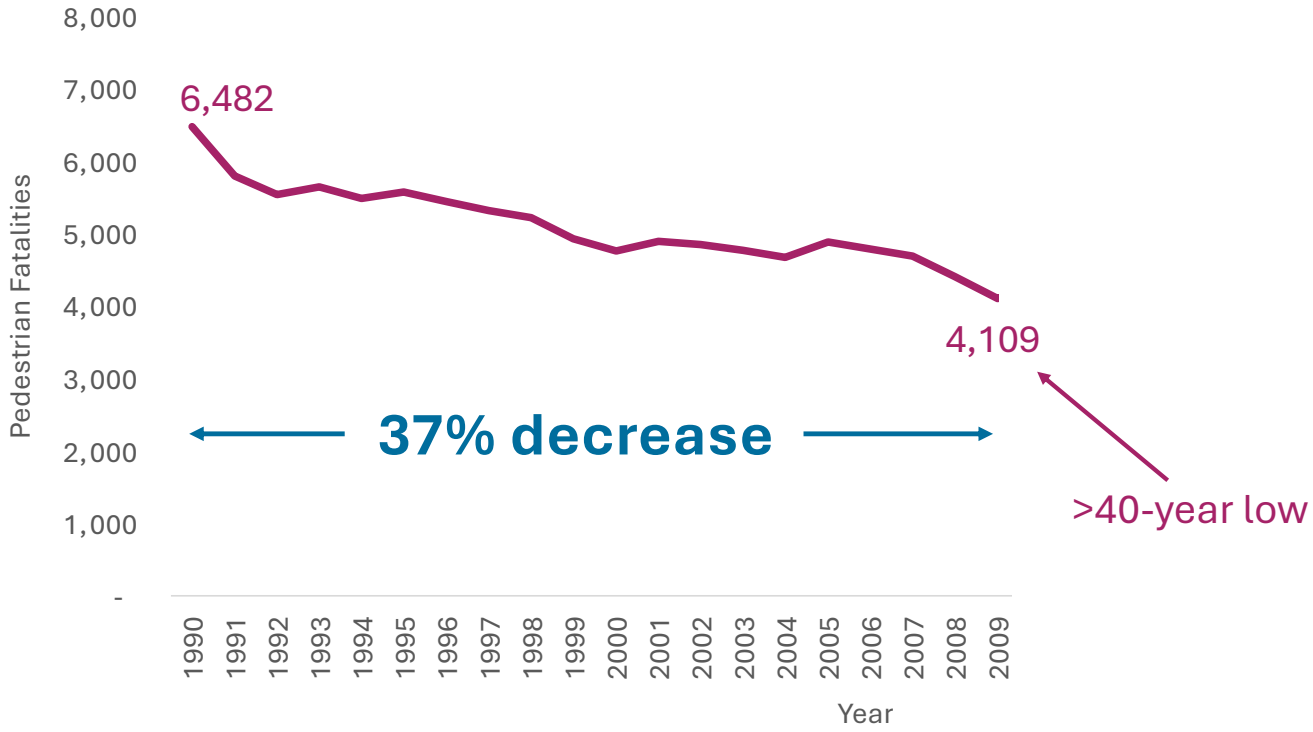
Texas Pedestrian Safety Forum, June 17, 2025

Overview

- National Trends & Background
- Recent Research Findings
  - NCHRP 17-97
- Proven and Promising Strategies and Tools
  - Safe Roadway Design
  - Beyond Roadway Design
- Inspiring Examples

Photo credit: Safe Streets Research & Consulting

U.S. Pedestrian Fatalities, 1990-2009



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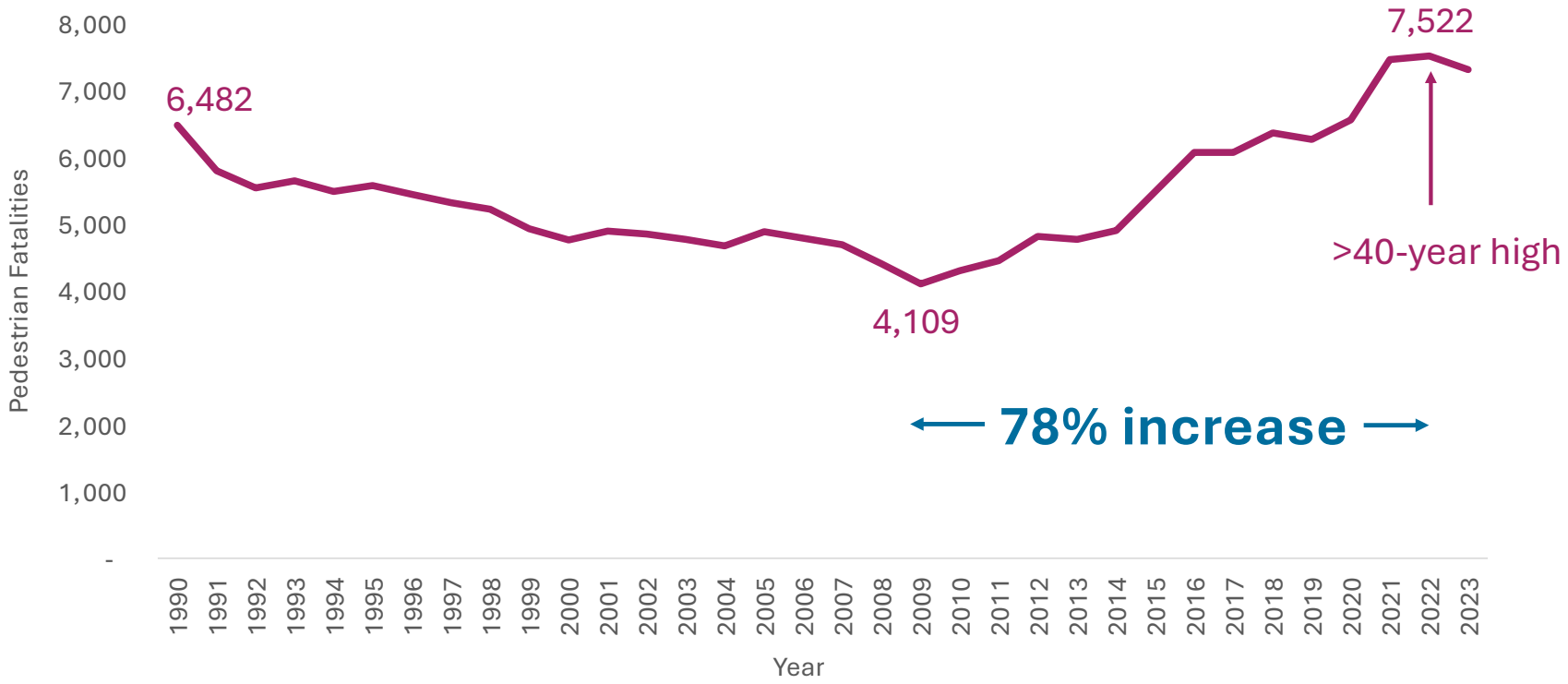
Data source: Fatality Analysis Reporting System (FARS)

U.S. Pedestrian Fatalities, 1990-2023



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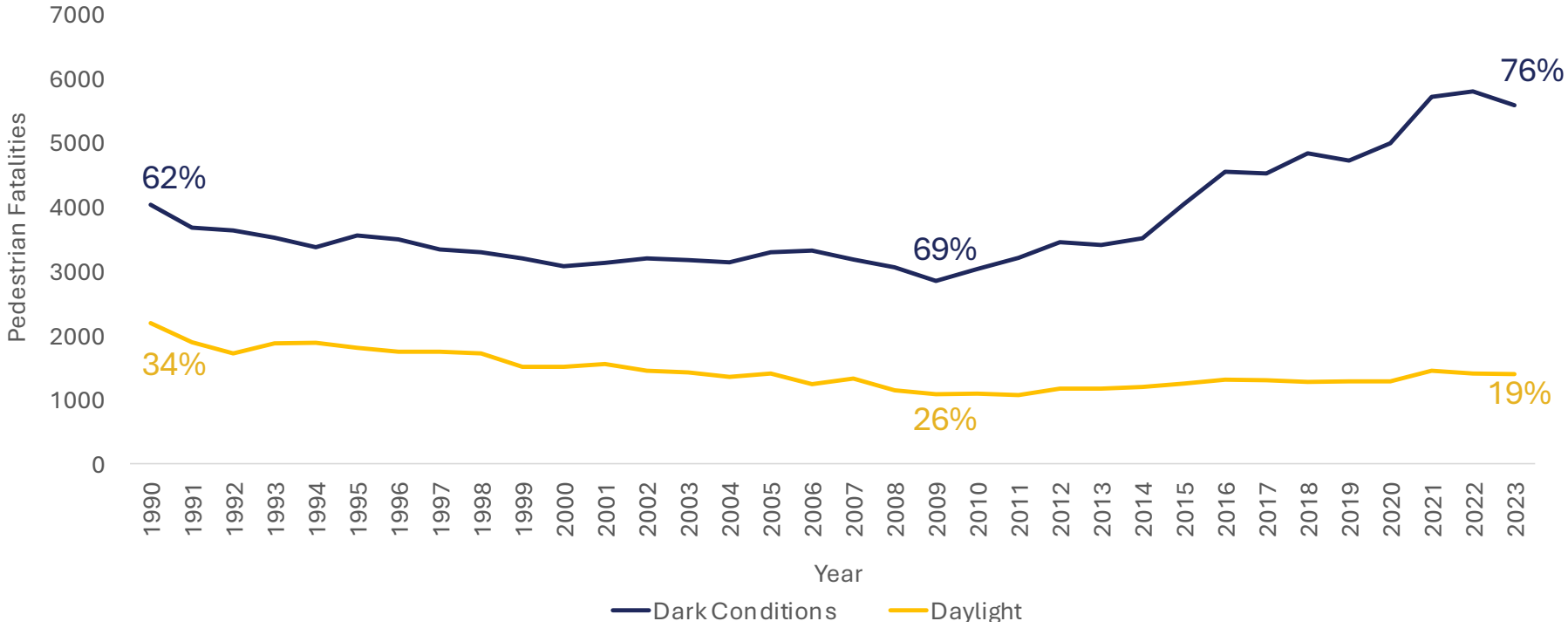
U.S. Pedestrian Fatalities in Daylight and Dark Conditions, 1990-2023



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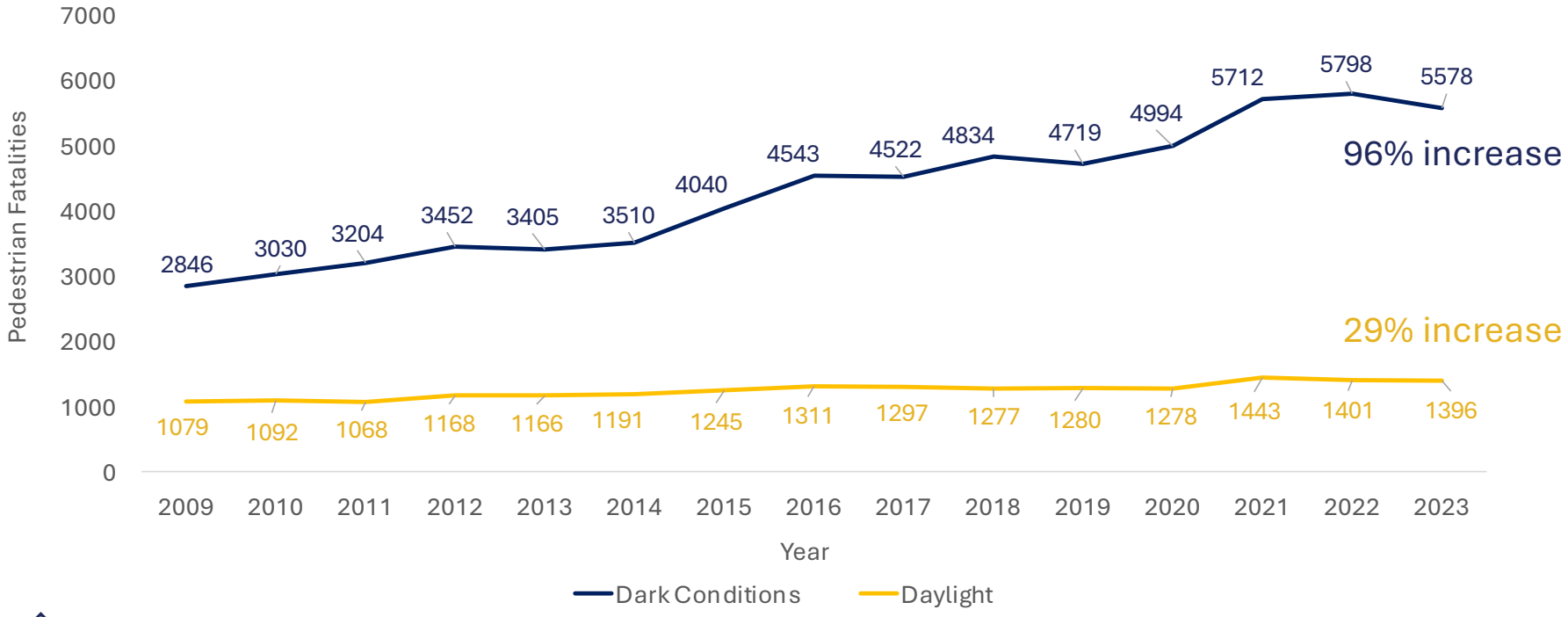

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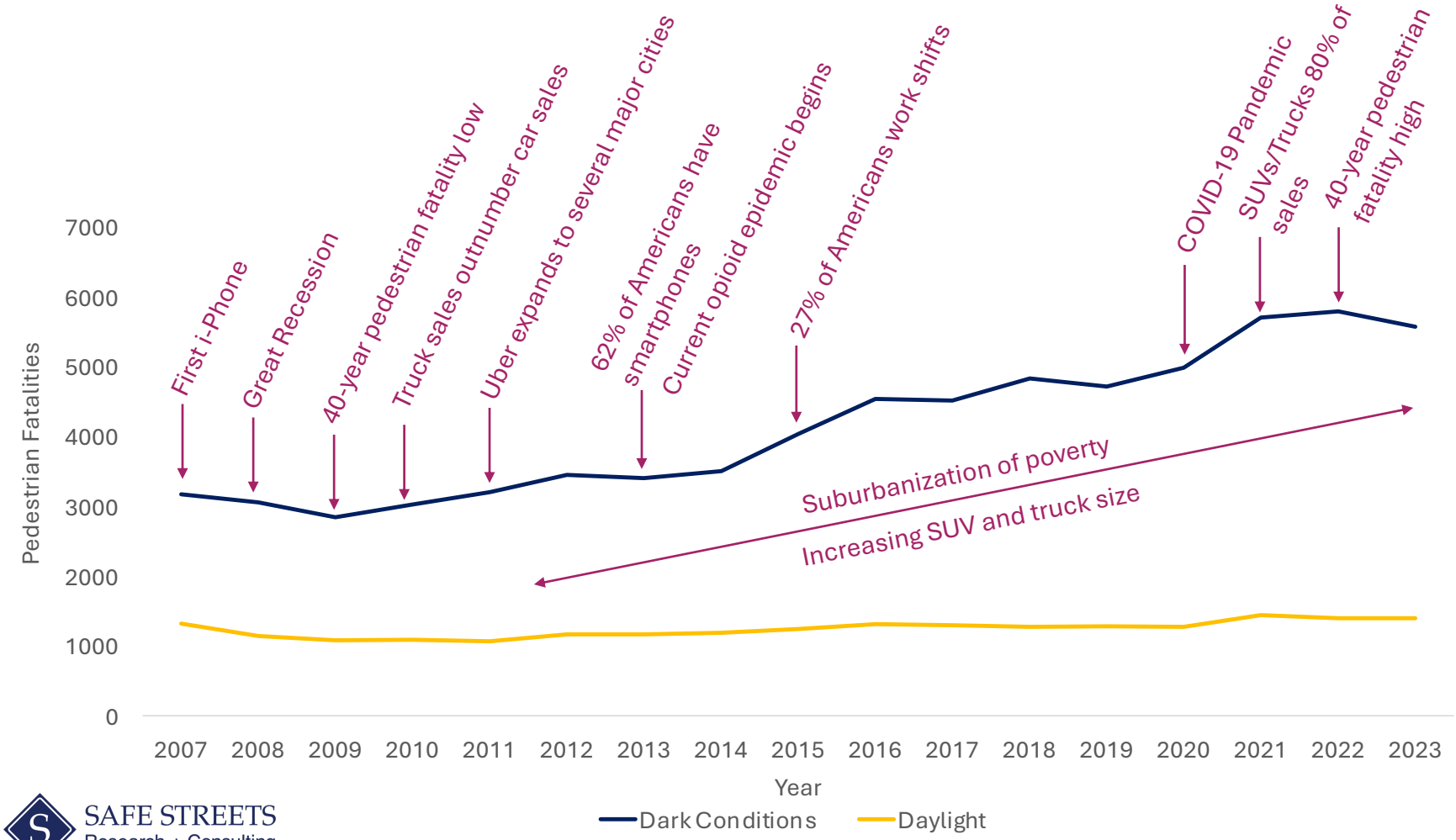
Data source: Fatality Analysis Reporting System (FARS)

Factors Impacting Pedestrian Safety Over Time



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Data source: Fatality Analysis Reporting System (FARS)

Recent Research Findings

NCHRP 17-97 Strategies to Improve Pedestrian Safety at Night

Photo credit: Bob Schneider

TOOLE DESIGN

SAFE STREETS Research + Consulting

UNIVERSITY OF WISCONSIN MILWAUKEE

Oregon State University

Project Overview

Phase I Investigation

- Comprehensive Literature Review (150+ sources)
- State-of-the-Practice Survey

Phase II Research

- Macro-level National Fatality Trend Analysis
- Micro-level Case Control Analysis
- Driving Simulator Study
- Pedestrian and Driver Focus Groups
- Practitioner Interviews

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We have known about this problem for a long time and see it in many kinds of data

National Highway Safety Board (1971)

“Illumination—or perceptibility of each other by driver and pedestrian—appears to be clearly involved…” in pedestrian fatalities.

“In the cities studied, over half the fatalities occurred in the 8-hour period from **4 p.m. to midnight**. This is the period of homebound traffic, of social activities, and, especially in the **fall and winter months, of fewer daylight hours**.”

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National Transportation Safety Board (NTSB). (1971). Special Study: The Status of Pedestrian Traffic Safety Efforts of the Department of Transportation, NTSB-STS-71-2.

US Fatal Pedestrian Crashes by Month by Hour of Day, 1998-2007

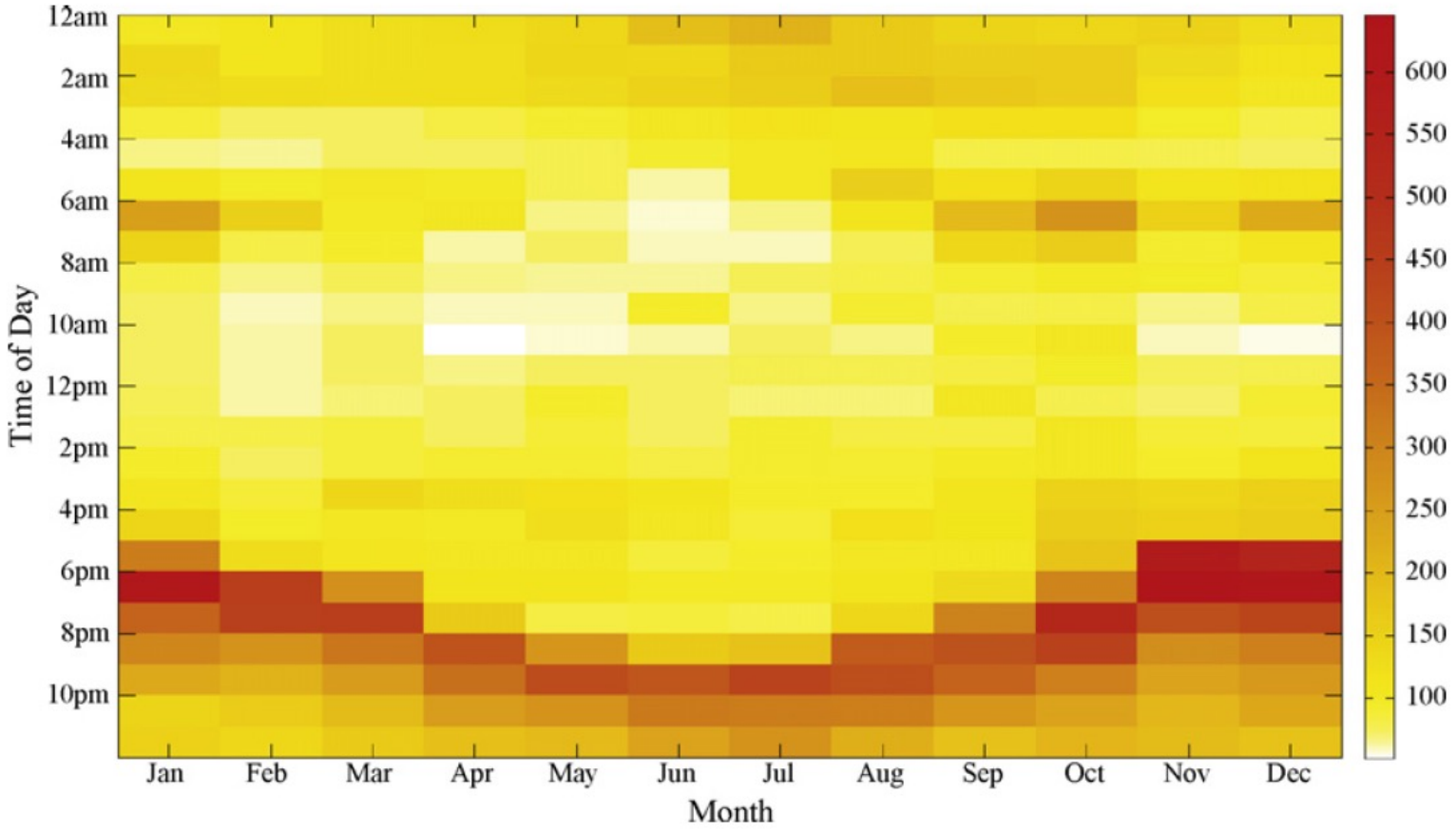


Fig. 1. Pedestrian fatal collisions by month and time of day.

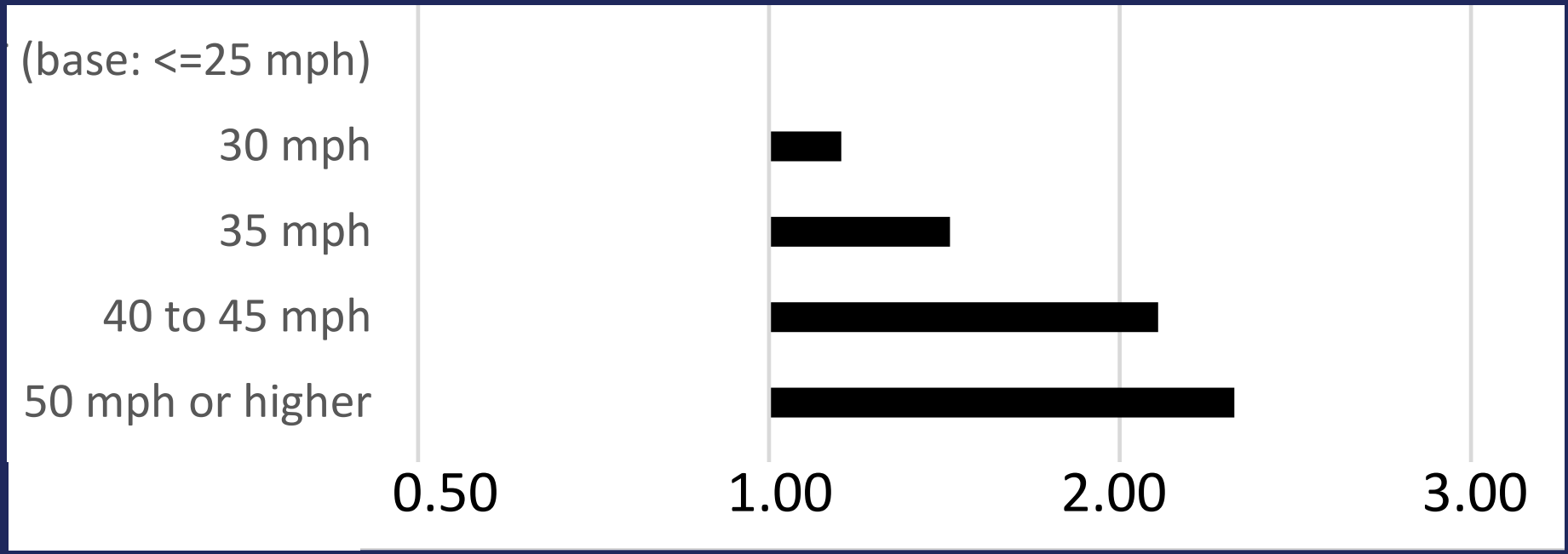
Source: Griswold, J., Fishbain, B., Washington, S. and Ragland, D.R. (2011). Visual assessment of pedestrian crashes. Accident Analysis & Prevention, 43(1), pp.301-306.

Our project data underscore the problem

Crash Analysis

01

Odds of Fatality occurring in Darkness: Speed Limit



Source: Fatality Analysis Reporting System: 2010-20, Binomial logistic regression analysis

Summary of preliminary findings from NCHRP 17-97: Strategies to Improve Pedestrian Safety at Night

National Crash Analysis Key Findings

Pedestrian fatalities in darkness associated with:

- Higher speed limits
- Driver going straight
- Multilane roadways
- Pedestrian being struck in roadway, no crosswalk, no sidewalk
- Rainy & snowy weather

In the dark and above certain speeds, drivers cannot see and react to pedestrians in the roadway in time to avoid hitting them.

Photo credit: Bob Schneider

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City-level Case Control Analysis

- Aimed to identify variables significantly associated with the likelihood of a fatal or serious pedestrian injury in darkness *within higher-risk environments*.
- City-level
  - Charlotte, NC
  - Detroit, MI
  - Houston, TX
  - Los Angeles, CA
  - Portland, OR
  - San Diego, CA

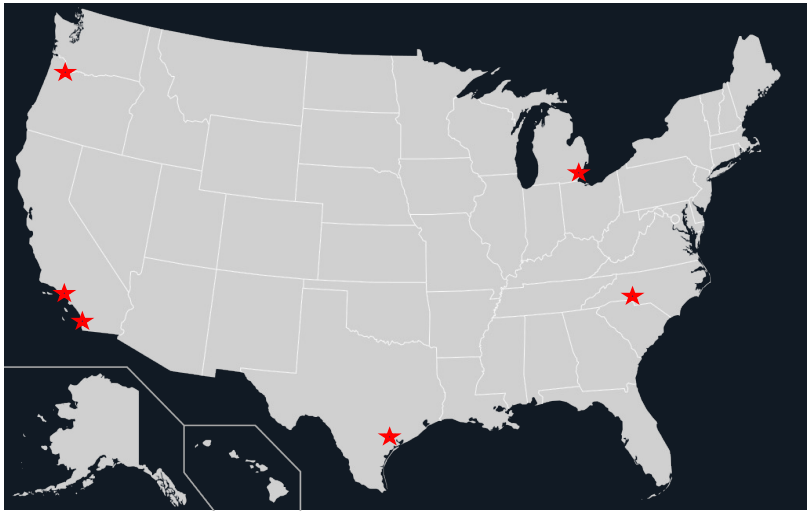

Image credit: WikiMedia Commons

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Findings: Design + Demographics

- Max number of through lanes in one direction (+)
- EPA SLD multimodal network density variable (-)
- Higher percentages of Black or Hispanic/Latino residents (+)

Photo Credit: www.pedbikeimages.org / Charles Hamlett

Findings: Pedestrian Attractors

- Convenience stores, grocery stores, liquor stores, and general low-density commercial design (+)
- National Walkability Index score (+)
- Low-density residential areas (-)

Photo credit: NCHRP 17-97/Toole Design

Driving Simulator Study

02

Study Experiment

Dr. David Hurwitz Dr. Hisham Jashami, RSP[1] Kezia Suwandhaputra, MSCE

Oregon State University

Photo credits: NCHRP 17-97/Oregon State University

Experimental Design

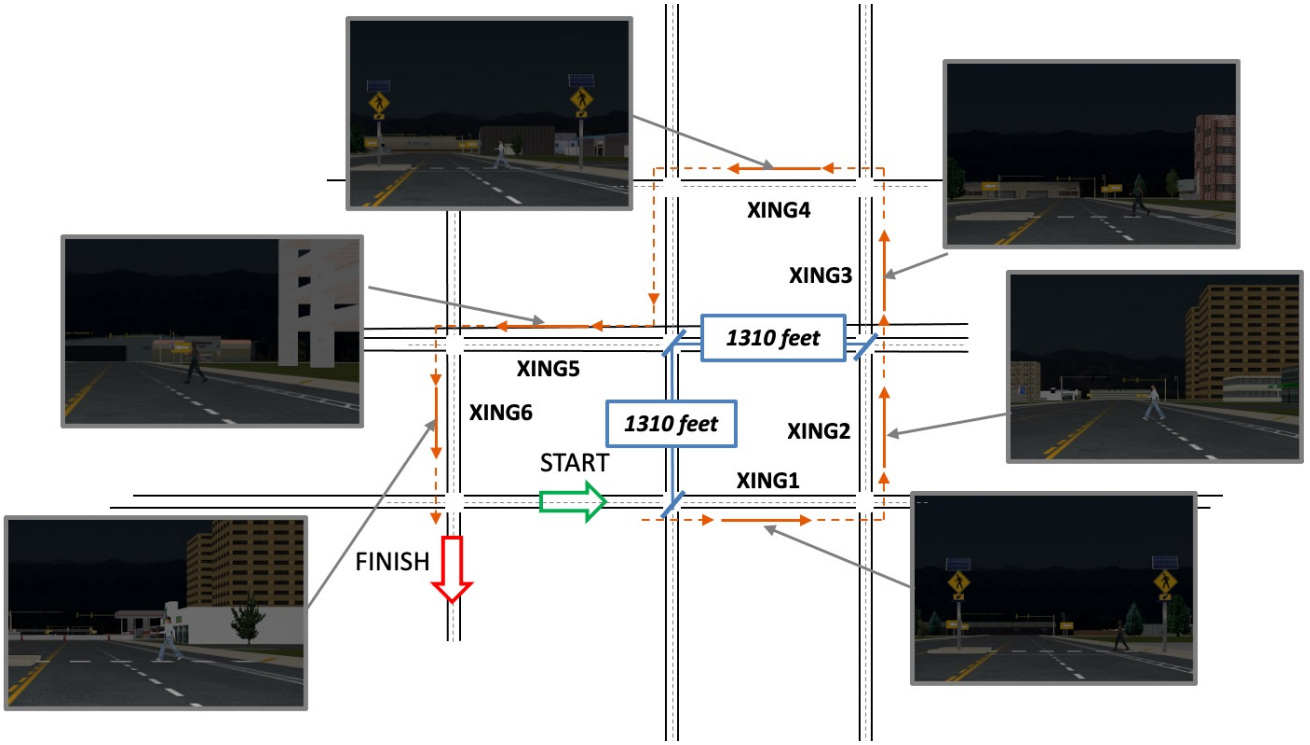
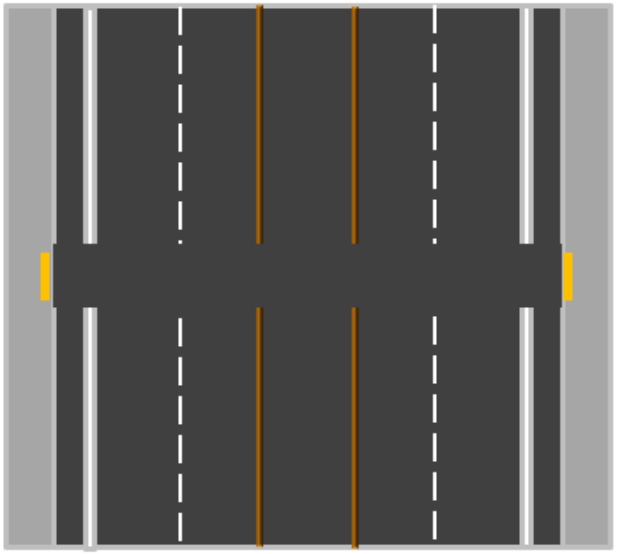


Image credit: NCHRP 17-97/Oregon State University

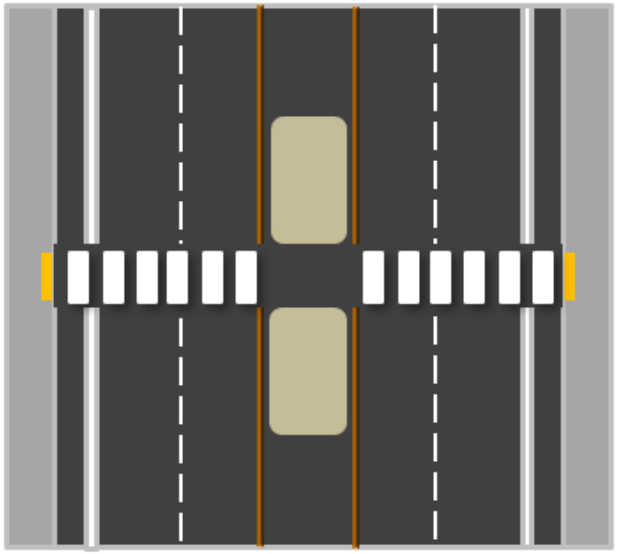
Pedestrian Crossing Types Tested

Unmarked



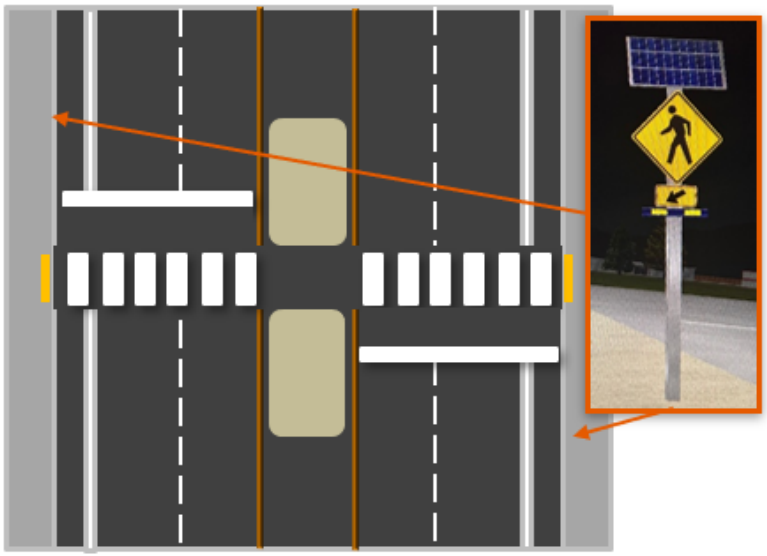
A

High-vis crosswalk



B

w/RRFB

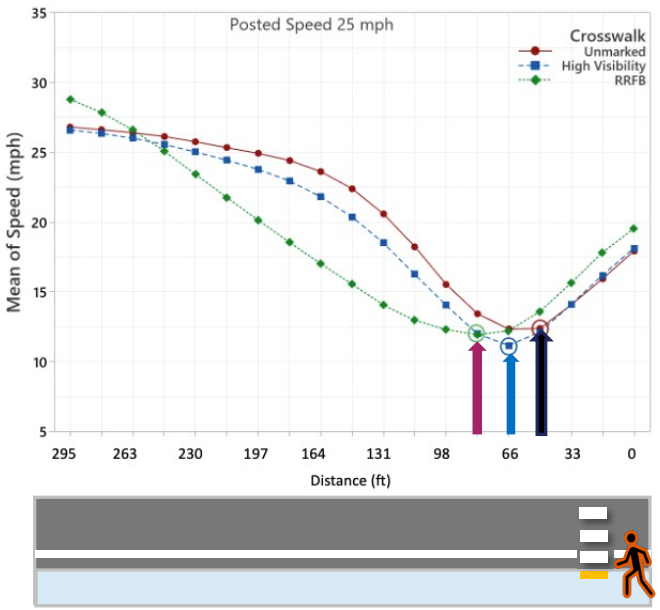


C

Image credits: NCHRP 17-97/Oregon State University

Simulator Findings: Speed Limit

Speed Limit: 25 mph



Speed Limit: 40 mph

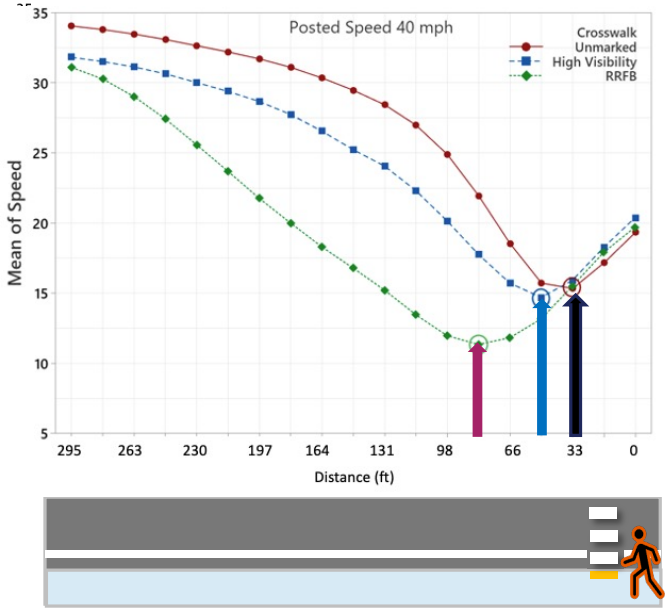


Image credits: NCHRP 17-97/Oregon State University

Summary of Research Findings

03

Higher Roadway Speeds Create Pedestrian Risk

- ↓ driver detection and reaction time
- ↑ stopping distance
- ↑ kinetic energy transfer

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Photo Credit: NCHRP 17-97/Toole Design

Darkness is a Critical Risk Factor for Pedestrian Safety

- Drivers underestimate darkness impairment
- Reduced detection-reaction time
- Higher driver stress near pedestrians
- Pedestrians feel less safe

Photo Credit: NCHRP 17-97/Toole Design

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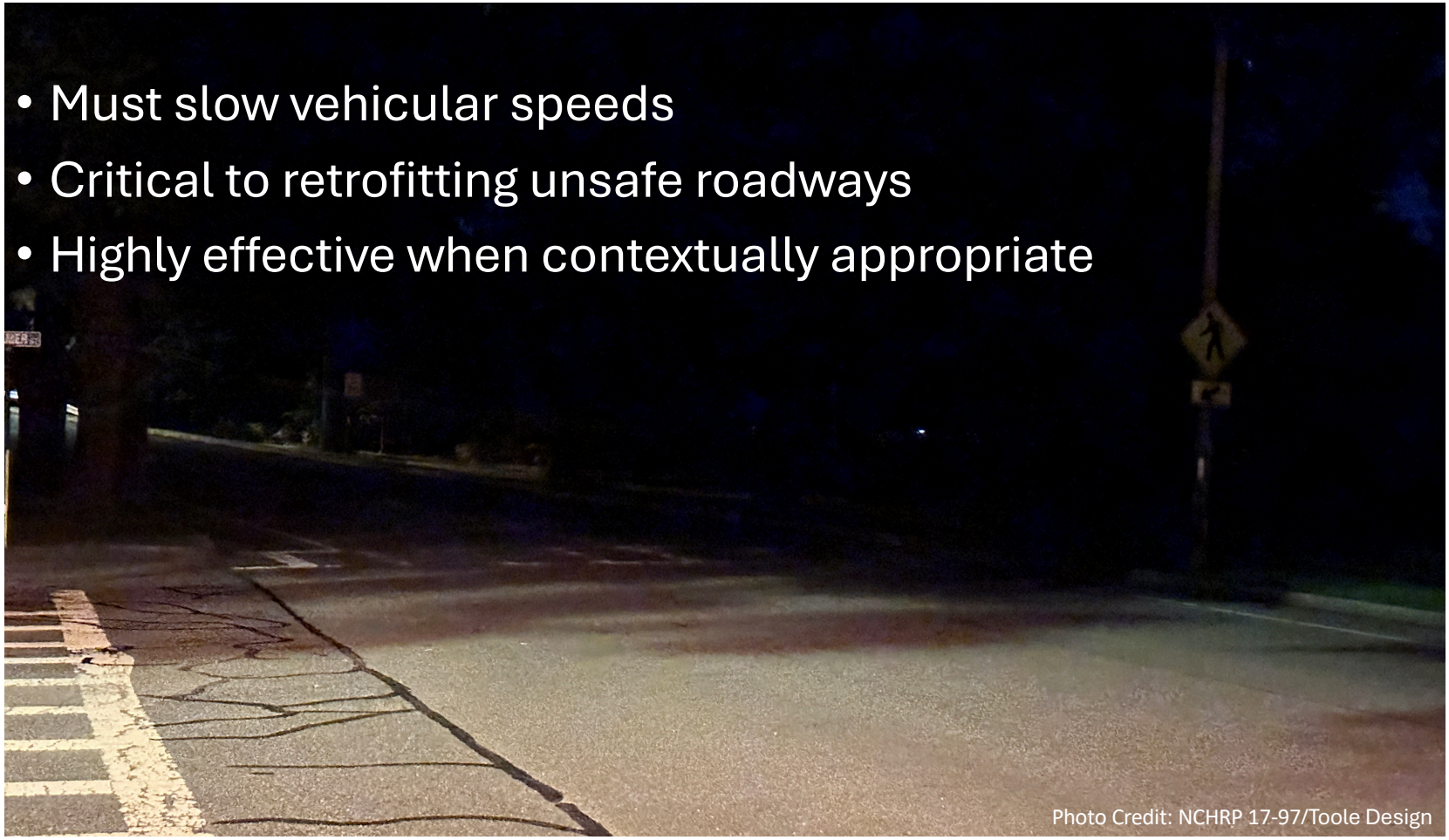
Countermeasures are an Important Part of the Solution



Context is Critical to Reducing Pedestrian Crash Risk

- Attractors significantly associated with fatal and serious injuries
- Drivers react to pedestrian-supportive environments

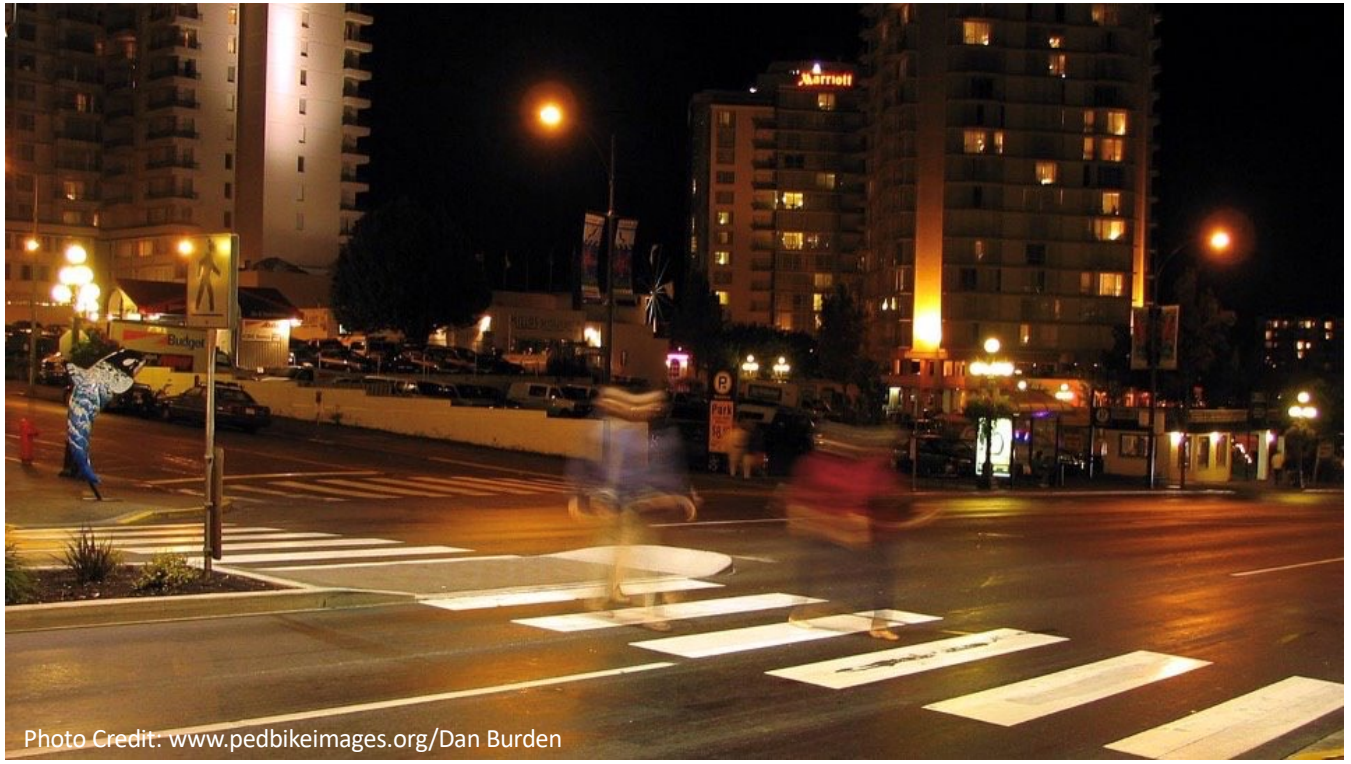


Photo Credit: www.pedbikeimages.org/Dan Burden

Nighttime Behaviors Increase the Likelihood of a Crash

- Speed
- Impairment
- Distraction

Image Credit: NCHRP 17-97

Image Credit: Tyndall Air Base

Traffic Safety is an Equity Issue

- Clear disparities in the data
- Drivers take longer to recognize darker skin
- Women, particularly women of color, more concerned about safety than men

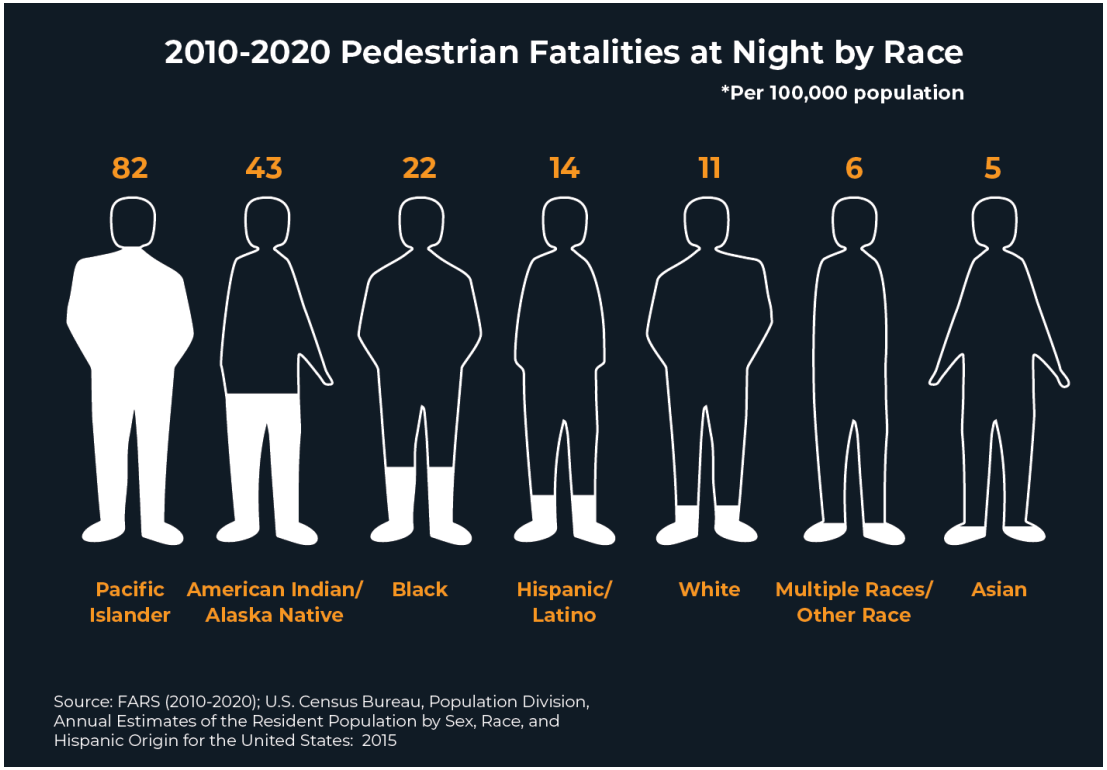


Image Credit: NCHRP 17-97

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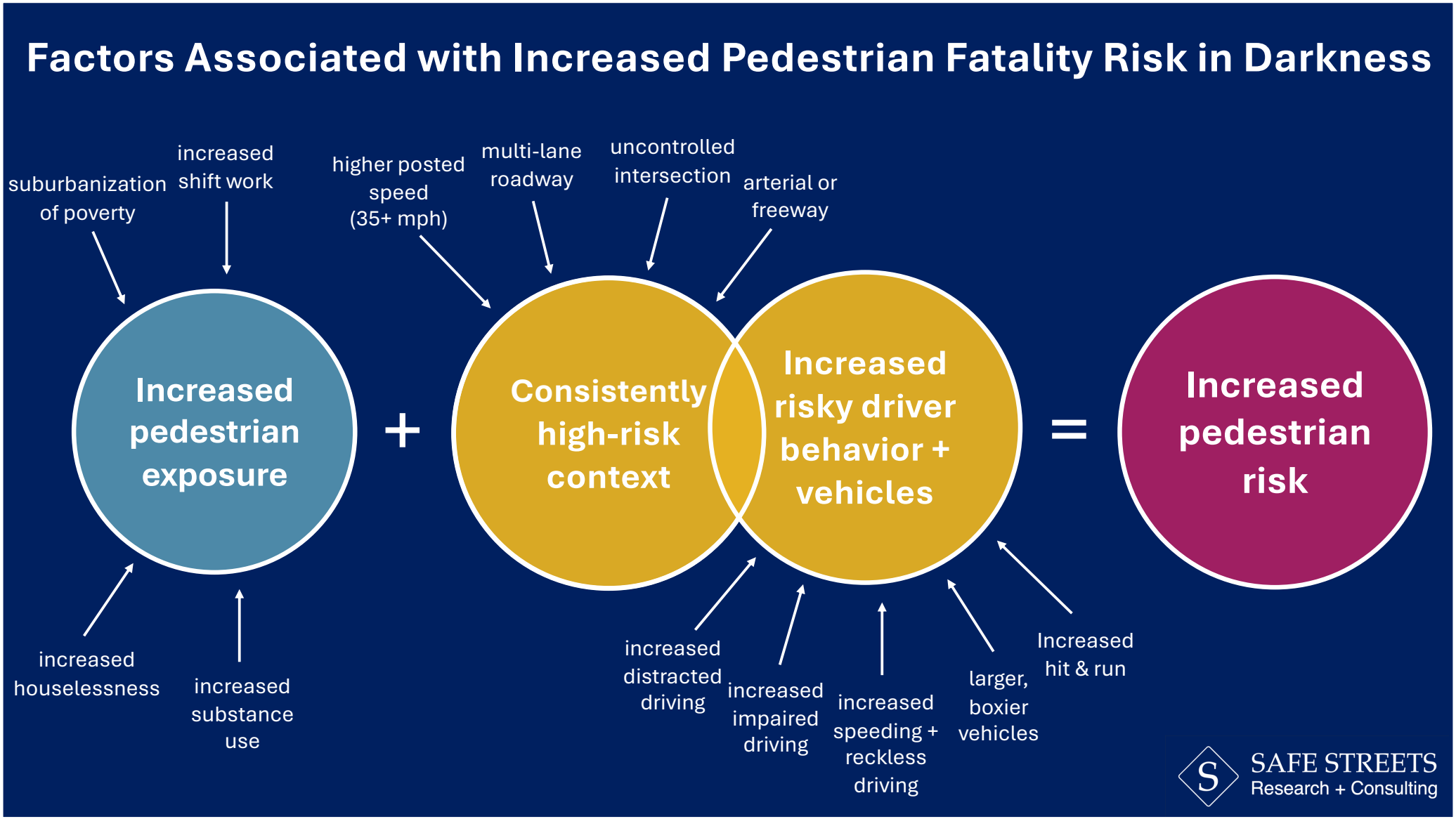
Factors Associated with Increased Pedestrian Fatality Risk in Darkness



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We can do something about this problem

Guidance

Safe System Approach

1. Death/Serious Injury is Unacceptable
2. Humans Make Mistakes
3. Humans are Vulnerable
4. Safety is Proactive
5. Redundancy is Crucial
6. Responsibility is Shared

Image Credit: FHWA

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Safe System Pyramid for Pedestrian Safety at Night

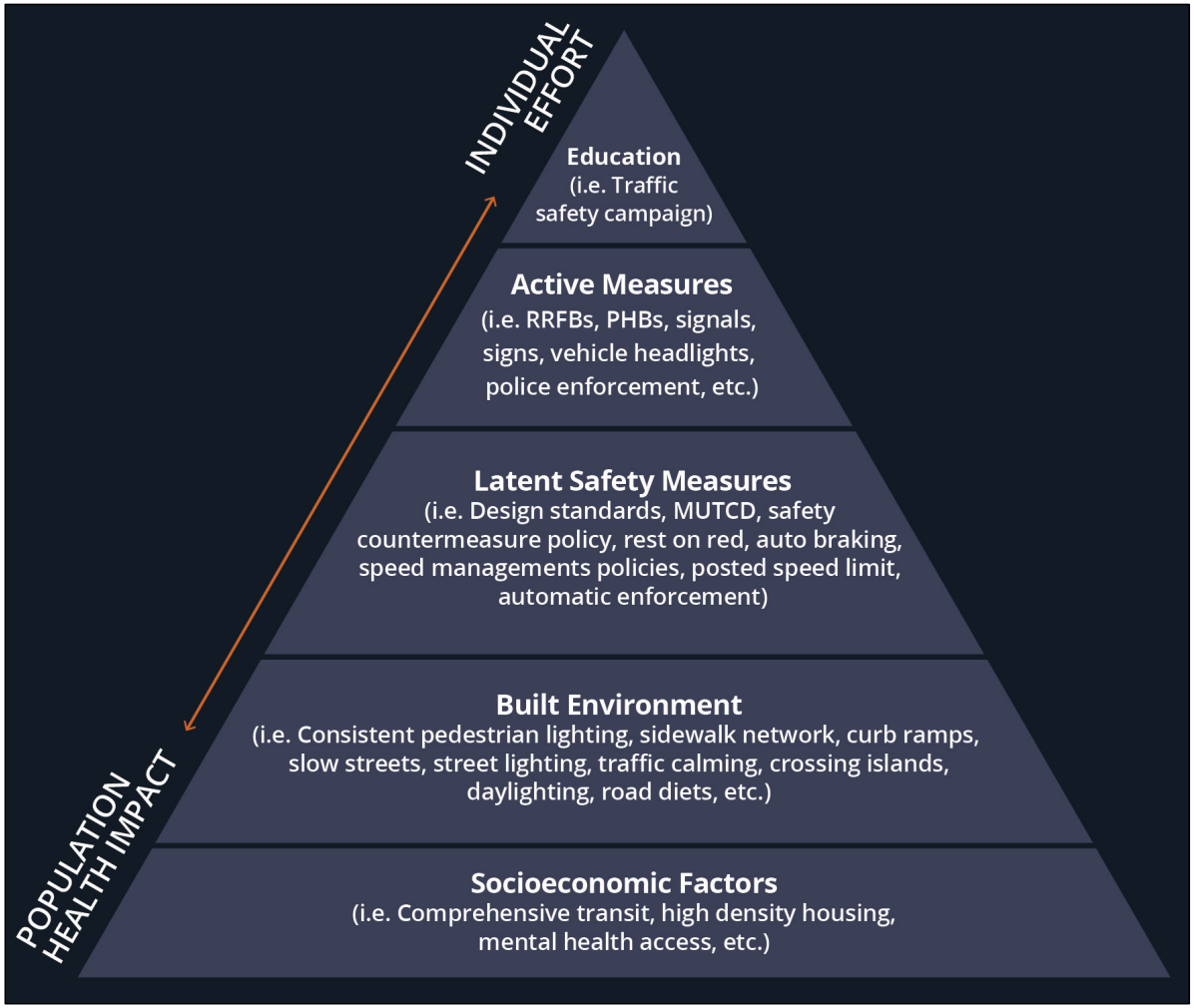

Image Credit: NCHRP 17-97

Adapted from: Ederer, D.J., Panik, R.T., Botchwey, N., & Watkins, K. 2023. The Safe Systems Pyra mid: A new framework for traffic safety, *Transportation Research Interdisciplinary Perspectives*, 21, 100905.

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FHWA's Elements of Risk

- Exposure
  - The presence or potential presence of someone to be involved in a crash, and the length of time they are exposed, →
    - Separate pedestrians from drivers in time and space
    - Shorten crossing distances
- Likelihood
  - Elements that impact the probability of crash occurrence, and →
    - Increase pedestrian visibility and the potential for driver detection
    - Slow driver speed to allow for detection
- Severity
  - Factors that impact the potential for a severe outcome →
    - Manage driver speed to reduce kinetic energy transfer

Source: FHWA Safe System Approach to Speed Management

Safe Roadway Design + Safe Speed

04

To improve safety for all roadway users, transportation professionals must design for the most vulnerable in the most challenging of scenarios - walking at night.

Improving safety at night also benefits the daytime

Photo Credit: Bob Schneider

Nighttime Countermeasures

Reduce the potential for a severe outcome through managing vehicle speeds

Decrease the likelihood of a crash through increasing driver awareness of pedestrians (enhancing visibility)

Reduce pedestrian exposure (i.e., the time pedestrians spend in the roadway)

Image Credits: NCHRP 17-97

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Manage Vehicular Speeds

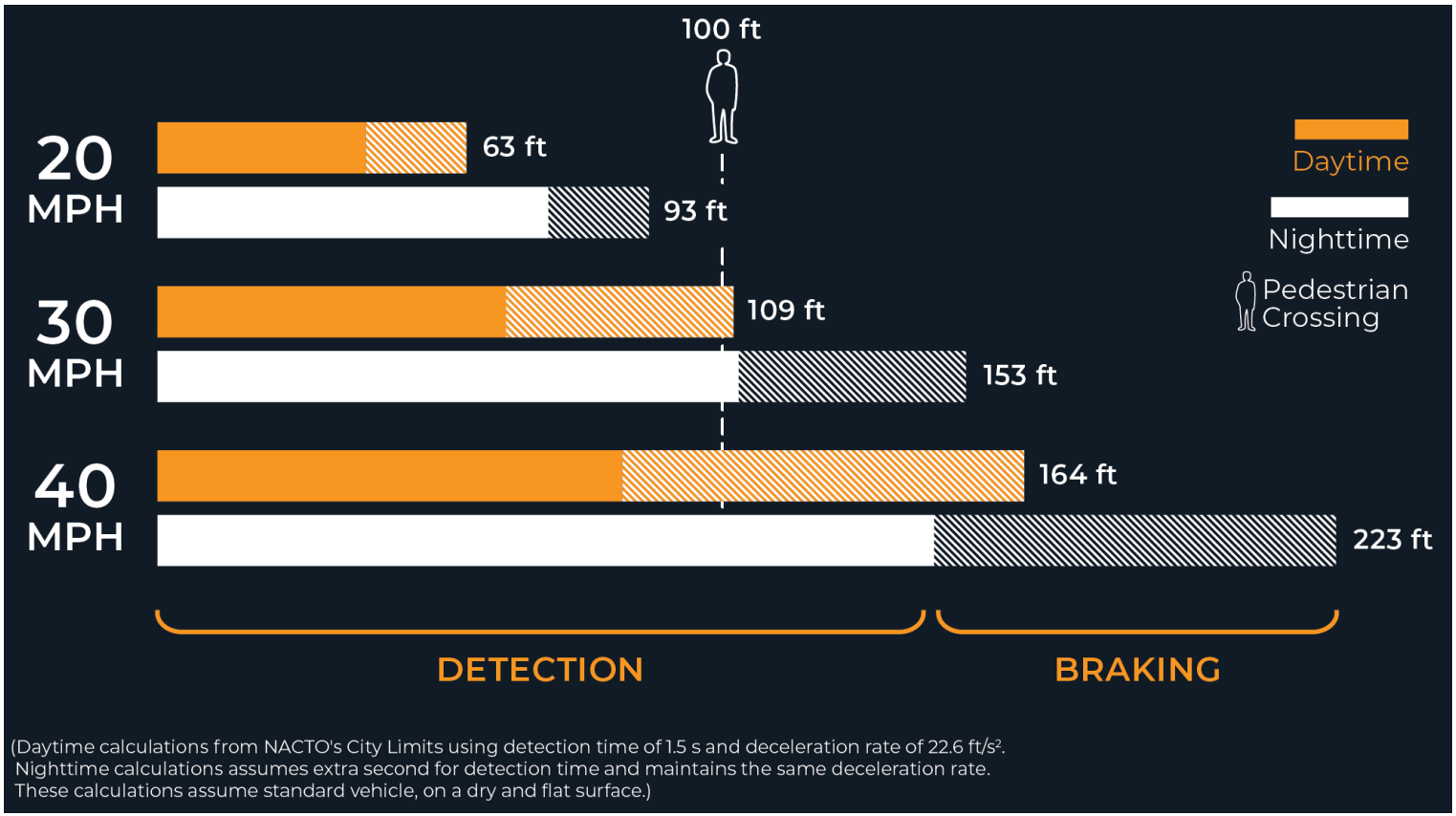
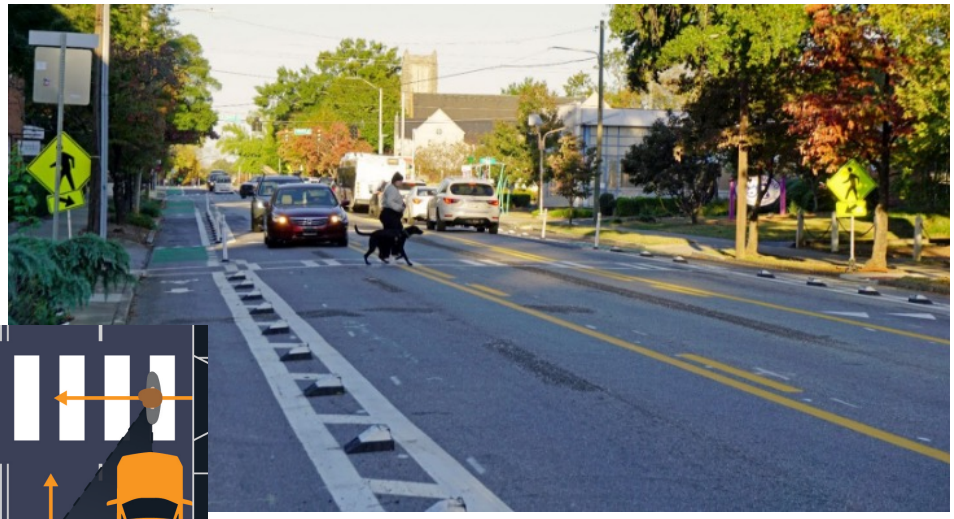
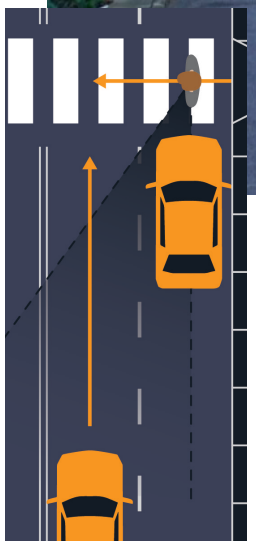


Image Credit: NCHRP 17-97

Manage Vehicular Speeds

- Nighttime Countermeasures
  - Roadway reallocations
  - Speed feedback signs
  - Automatic speed enforcement
  - Lower speed limits
  - Other traffic calming countermeasures





W13-20

R2-3P

Images: NCHRP 17-97 (above), MUTCD (both signs); Photo: NCHRP 17-97/Toole Design

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Enhance Visibility

- Roadways must clearly communicate to drivers the potential risk of a person walking or crossing the road
- Nighttime Countermeasures
  - Lighting
  - Marked crosswalks
  - Traffic control devices
    - Traffic signals
    - Pedestrian hybrid beacons
    - Rectangular rapid flashing beacons

Photo Credit: NCHRP 17-97/Toole Design

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Marked Crosswalks

- Install high-visibility crosswalks at appropriate spacing depending on context and land use (see NCHRP 1036).
  - In urban core, the maximum crosswalk spacing is 300 feet (or one block).
  - In other urban contexts, the maximum crosswalk spacing is 500 feet (or two blocks).
  - In suburban context, the maximum crosswalk spacing is 1,000 feet (or 3-4 blocks).

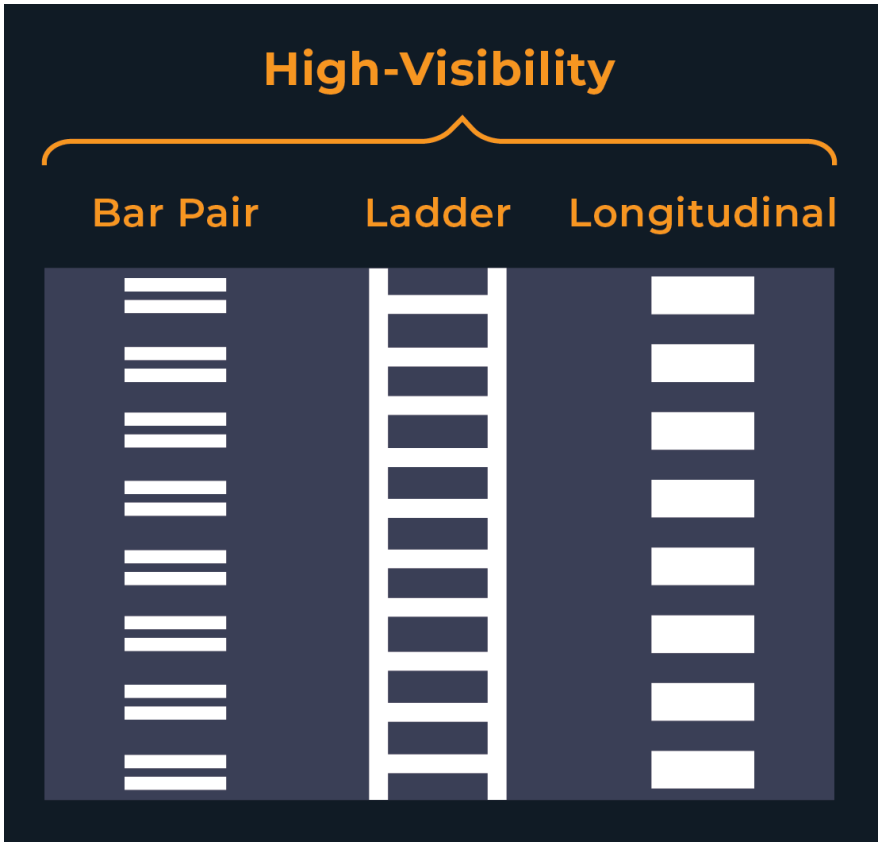

Image Credit: NCHRP 17-97

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Traffic Control Devices

- Traffic signals
- Pedestrian Hybrid Beacons (PHBs)
- Rectangular Rapid Flashing Beacons (RRFBs)

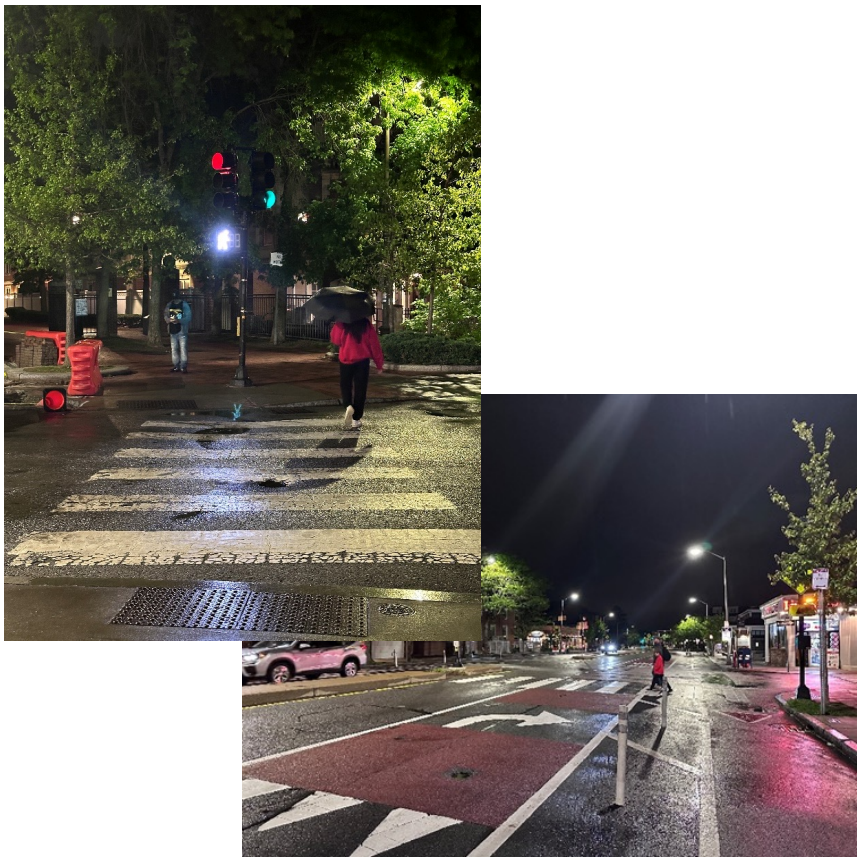

Photo Credits: NCHRP 17-97/Toole Design

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Pedestrian Hybrid Beacons (PHBs)

- MUTCD (2023) suggests installing a PHB on any roadway when a minimum of 20 pedestrians per hour have been observed to cross
- Our research recommends using new criteria which removes the minimum pedestrian volume and defers to professional judgement about need

Photo Credit: Safe Streets Research & Consulting

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Improve Roadway Lighting

Photo Credit: NCHRP 17-97/Toole Design

Implement Corridor-wide Lighting

- Within a commercial district with nighttime activity and destinations.
- Where there are high volumes of pedestrian activity during darkness.
- Within ½ mile of a transportation center.
- Within ¼ mile of a major transit stop or station.
- Within ½ mile of an institution or educational facility with nighttime pedestrian trips.

Photo Credit: NCHRP 17-97/Toole Design

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Design Considerations for Spot Lighting

- Illuminate locations with known pedestrian safety and/or security issues (e.g., underpasses).

- Ensure that street features do not block the light from reaching the roadway/pedestrian facilities.

Photo Credits: NCHRP 17-97/Toole Design

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Design Considerations for Spot Lighting

- Illuminate key aspects of the roadway such as user conflict areas and complex conditions.
- Install lighting in advance of mid-block crossings and intersections.

Photo Credit: NCHRP 17-97/Toole Design

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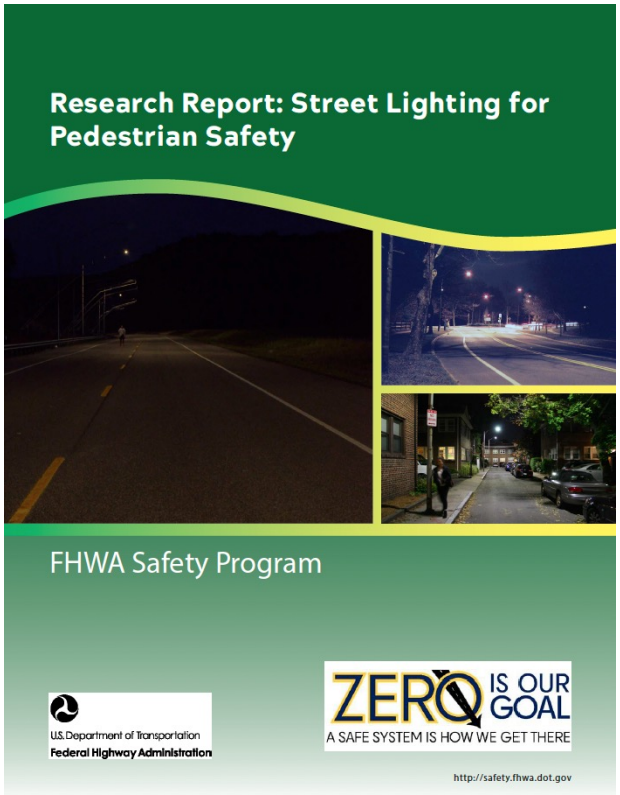
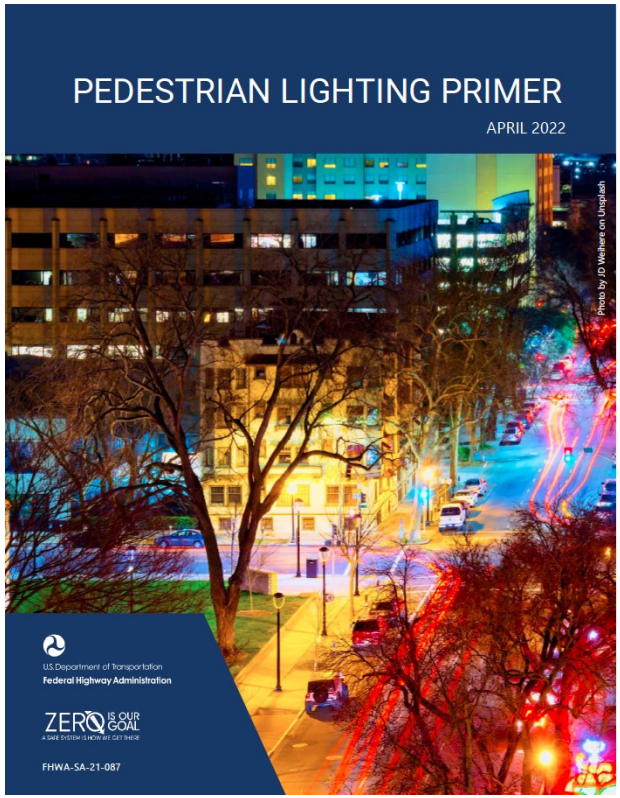
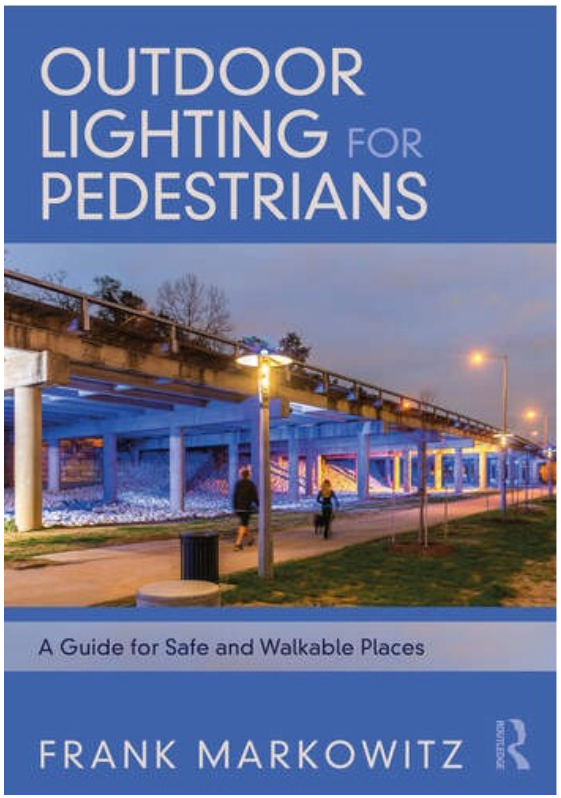
Lighting Resources







Lighting is necessary but not sufficient in high-risk environments.

Reduce Pedestrian Exposure

- Reduce the amount of time the pedestrian spends in the roadway
  - Essential at night when driver visibility is limited due to darkness
  - Essential on higher-speed, multilane roadways

Photo Credit: Safe Streets Research & Consulting

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Provide Sidewalks

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Photo Credits: NCHRP 17-97/Toole Design

Shorten Crossings Using Bulb-outs and Refuges

Photo Credit: NACTO

Photo Credit: SFMTA

Putting it Together

- Prioritize corridors where pedestrians have a greater risk at night
- Implement countermeasures that manage speeds, enhance visibility, and reduce exposure
- Consider land use and context
- Consider nighttime pedestrian generators
- Consider high-speed, multilane roads that lack pedestrian infrastructure

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Priority Scenarios

- Commercial districts, convenience stores, grocery stores, liquor stores
- Transit stations/stops
- Entertainment districts
- High-density residential areas
- Higher posted speeds, especially on arterials
- Multiple lanes, especially on arterials
- Lack sidewalks

Nighttime Countermeasures

Countermeasure	Pedestrian Risk Category		
	Manage Vehicular Speeds	Enhance Visibility	Reduce Pedestrian Exposure
Road Reallocations	√		*
Speed Feedback Signs	√		
Automatic Speed Enforcement	√		
Lower Speed Limits	√		
Lighting		√	
High-Visibility Marked Crosswalks		√	
Traffic Signals		√	
Pedestrian Hybrid Beacons		√	
Rectangular Rapid Flashing Beacons		√	
Daylighting/Curb Extensions	*	*	√
Crossing Islands	*		√
Sidewalks/Walkways/Shared Use Paths	*	*	√

Note: √ indicates the primary pedestrian risk category for that countermeasure and * indicates a secondary pedestrian risk category or categories.

Image Credit: NCHRP 17-97

Intersection Countermeasures

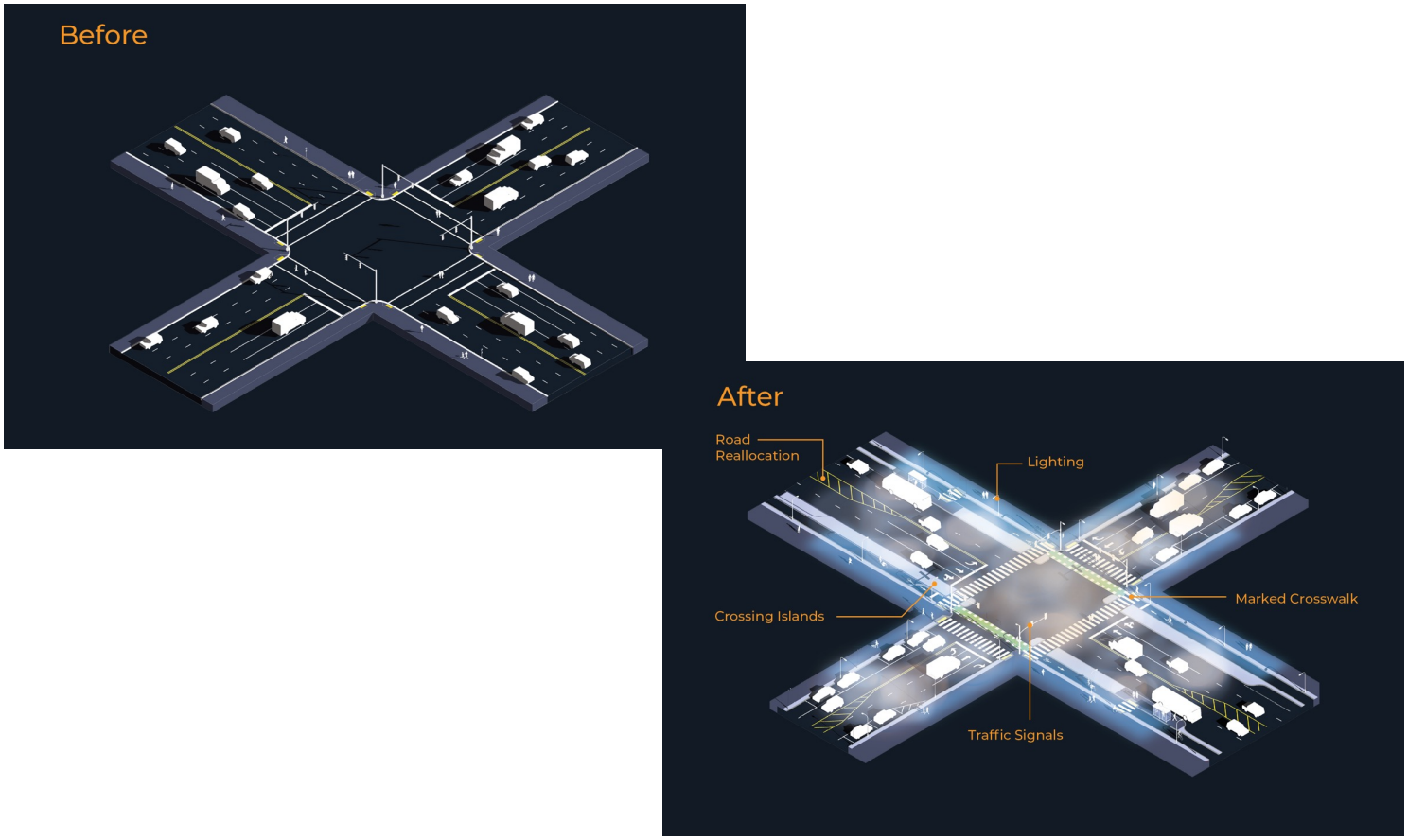

Image Credits: NCHRP 17-97

Mid-block Countermeasures

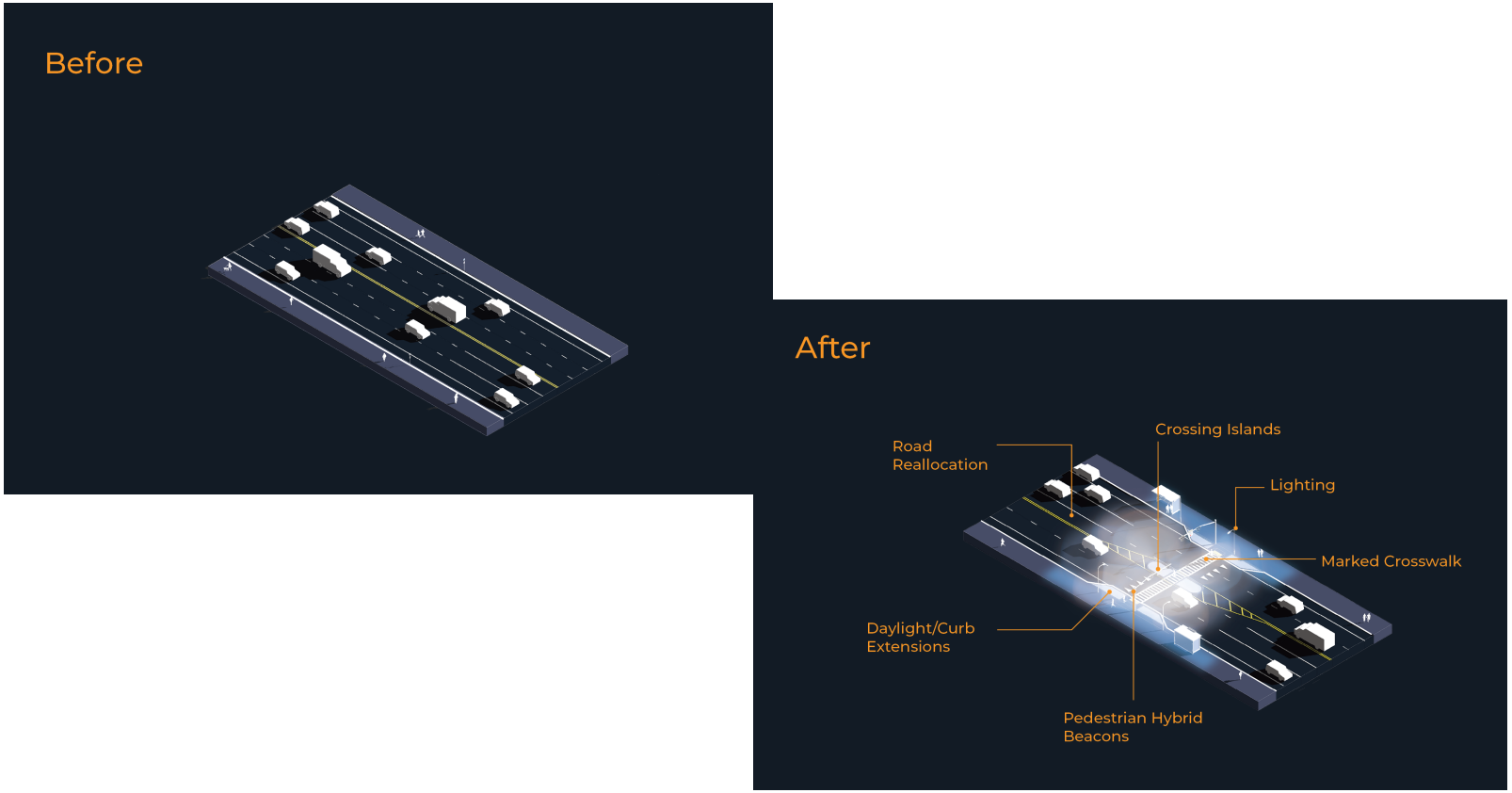

Image Credits: NCHRP 17-97

Beyond Roadway Design

05

Acknowledge Safety Impacts of Larger, Higher-risk Vehicles

- Install additional design and operational countermeasures
- Retrofit roadway design countermeasures
- Develop policies that reflect the higher risk of larger vehicles

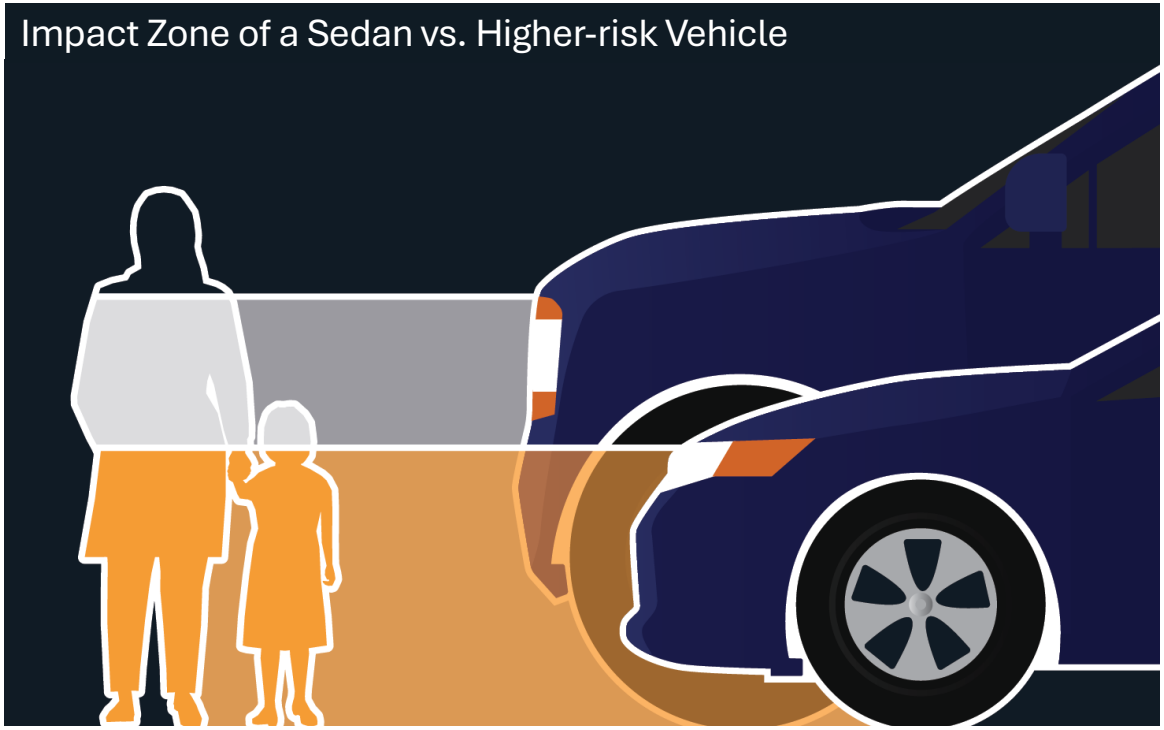

Image Credit: NCHRP 17-97

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Use Countermeasures to Help Address Higher-risk Vehicles

Install countermeasures to help address higher-risk vehicle designs, including:

- Widened crosswalks
- Recessed stop bars
- Restricted right turn on red
- Leading pedestrian and bike intervals
- Daylighting areas
- Tightened curb radii
- Centerline hardening
- Truck aprons

Photo Credit: NYC DOT

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Pursue Policy Solutions to Encourage Safer Vehicles

- Parking fee structure
- Weight taxes
- Agency fleet changes
- Mandated technology

Photo Credit: NCHRP 17-97/Toole Design

Technological Solutions to Increase Vehicle Safety

TRANSPORTATION

Vehicle Speed-Limiting Technology Gets a Foothold in State Law

A new Virginia law will allow judges to require intelligent speed assistance devices for people with repeat reckless driving offenses. Advocates are pushing for similar policies in other states.

Text credit: governing.com

After deadly Nevada crash, federal investigators want cars to warn drivers if they're speeding

Text credit: apnews.com

New laws punish bad drivers with tech that forces cars to go the speed limit

The technology aims to prevent vehicles from going over the speed limit. New laws lay out how the devices can be used to punish reckless driving.

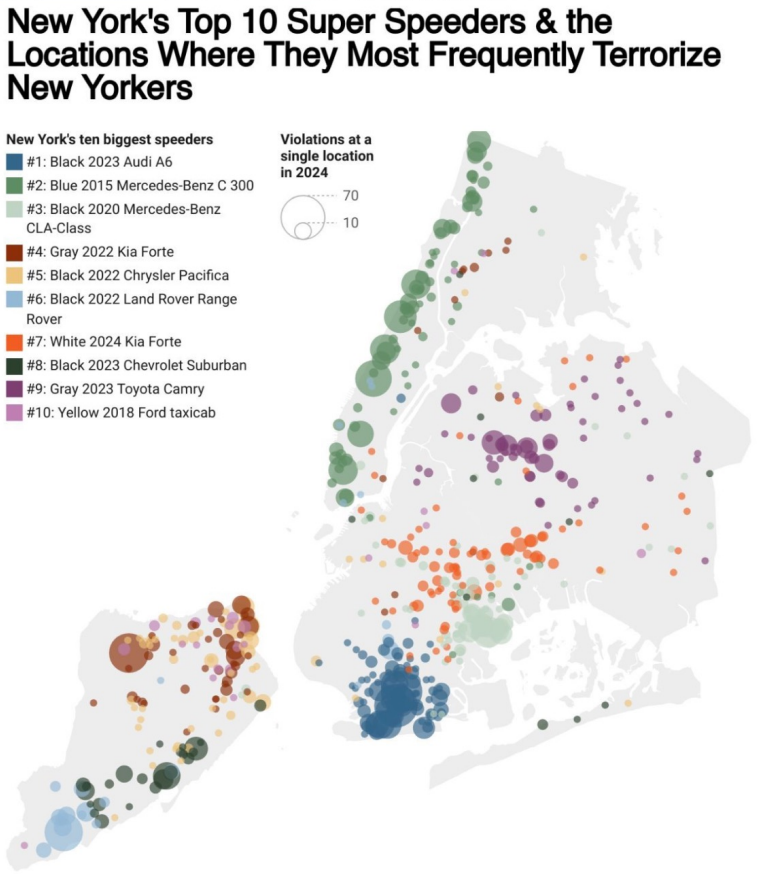
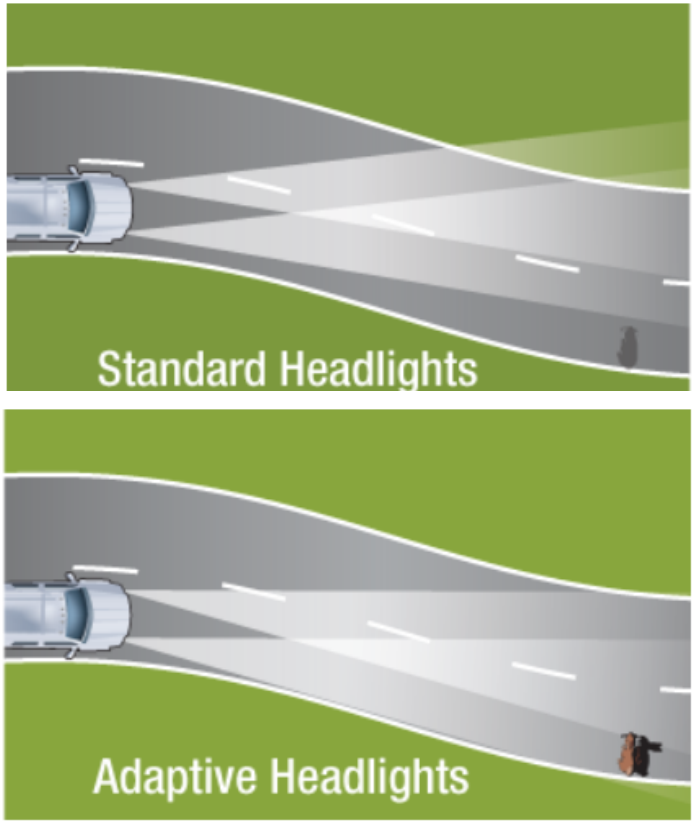
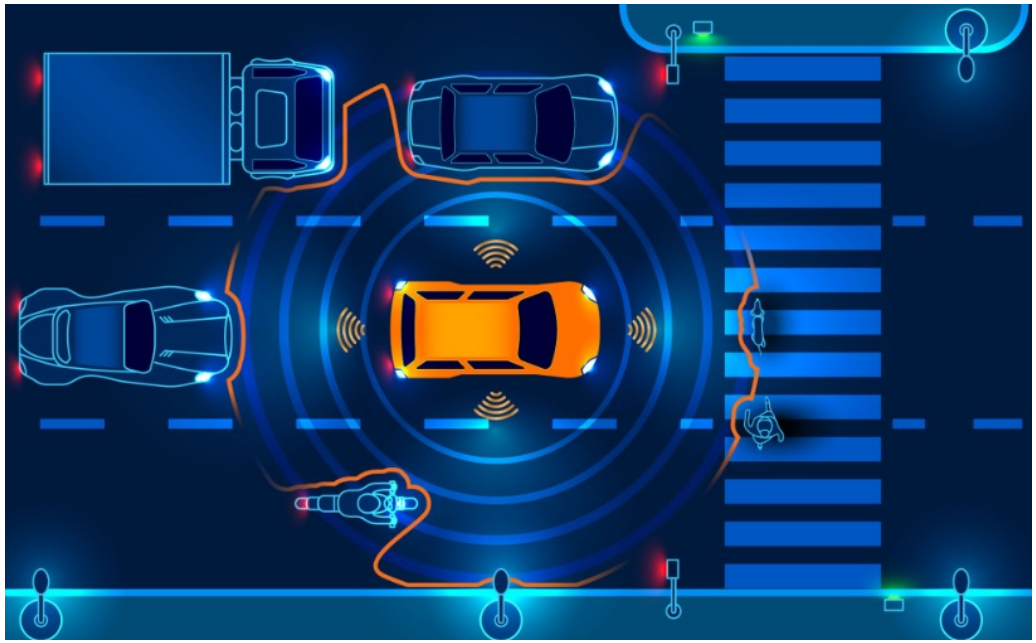


Image credit: Transportation Alternatives; Data Source: NYC Open Data; Created with Datawrapper

Adaptive Headlights and ADAS Features





Top Image Credit: Global Infrastructure Hub, GPS and Sensors to Enable Autonomous Vehicles, https://www.gihub.org/infrastructure-technology-use-cases/case-studies/gps-and-sensors-to-enable-autonomous-vehicles/, 2020.

Left Image Credit: My Car Does What? https://mycardoeswhat.org/safety-features/adaptive-headlights/, 2024.

Post-Crash Care Recommendations

Photo Credit: Valley Regional Fire

Data Collection, Analysis, & Countermeasure Selection

- Data collection
  - Work toward the latest MMUCC
  - Incorporate injury surveillance data
  - Create and maintain roadway data layers for systemic analysis
- Data analysis
  - Move from reactive to proactive
  - Focus on severe injury risk
  - Incorporate road safety audits
  - Create feedback loop with countermeasure selection

Image Credit: FHWA

Use Data to Tell a Story

- Identify the problem
- Identify potential solutions
- Measure the impact of investments
- Adjust course if necessary
- Tell the story

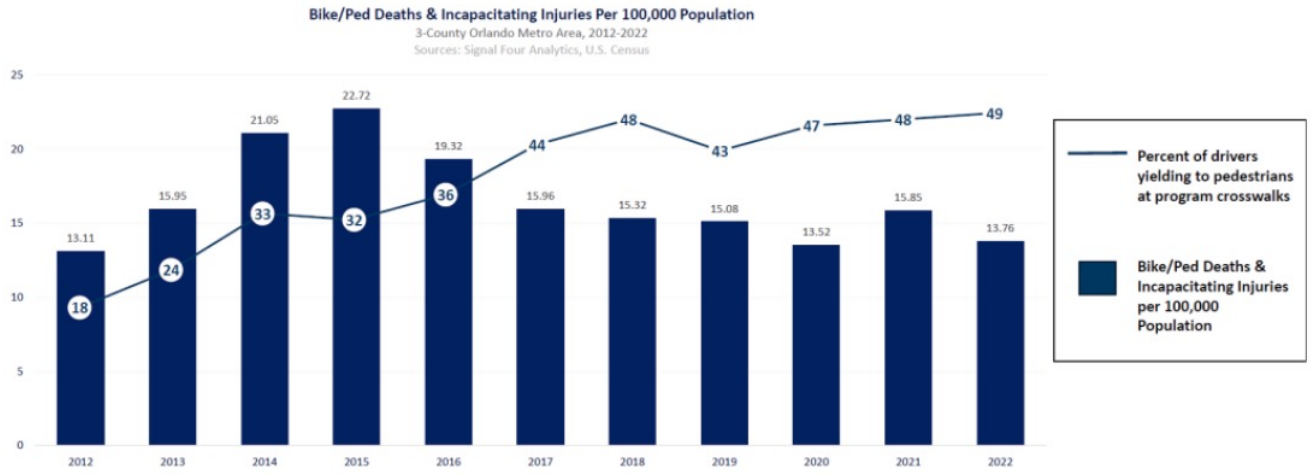


Image Credit: Bike/Walk Central Florida

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Fatal Pedestrian Crashes

Mid-Block during Dark Lighting Conditions, 2010-2020

Houston

Fatal Mid-Block Pedestrian Crash
- Daylight Lighting Condition
- Dark Lighting Condition

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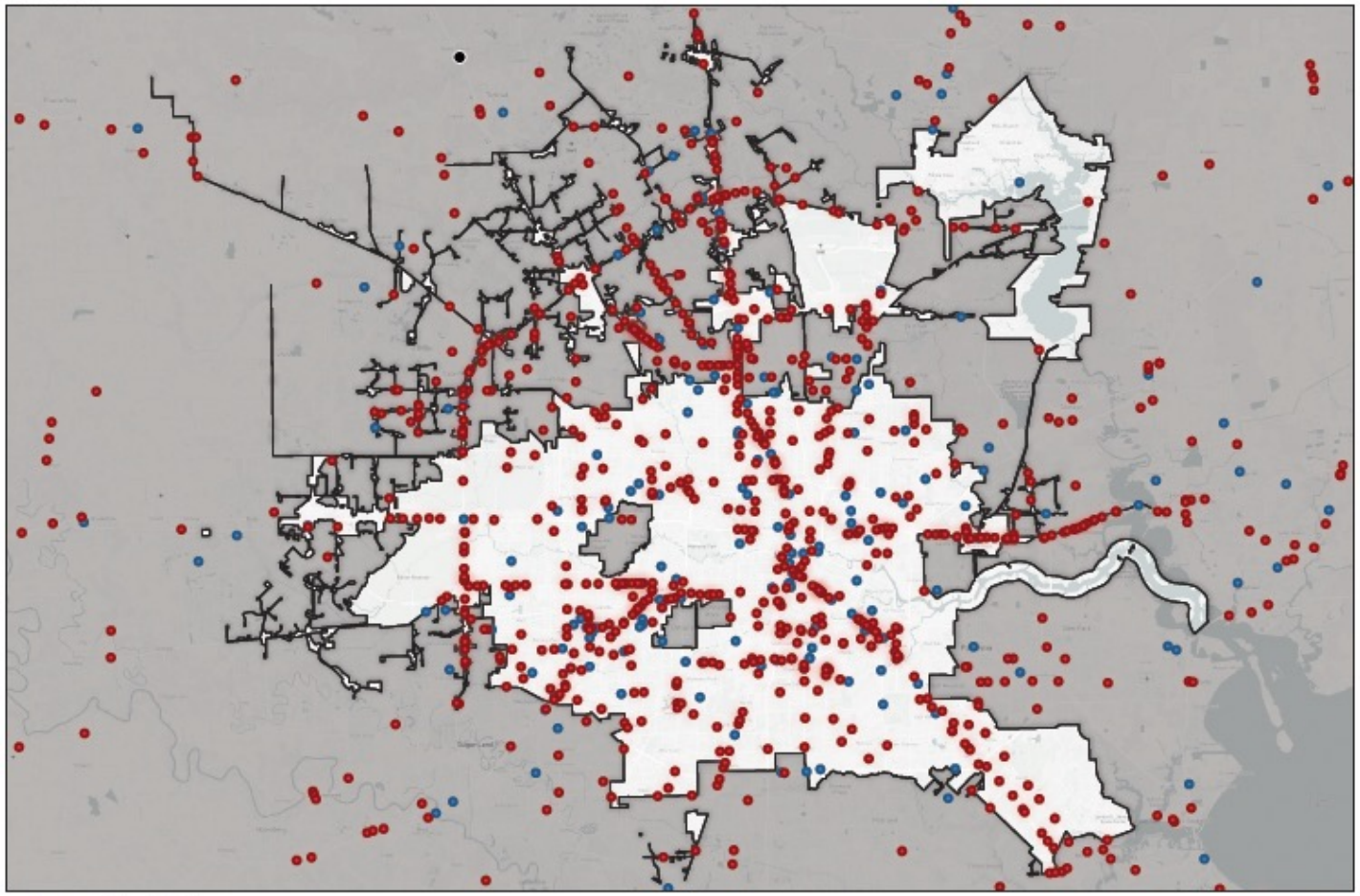


Image Credit: Safe Streets Research & Consulting

Data Source: Fatality Analysis Reporting System; Basemap: © Mapbox, © OpenStreetMap

Collaborate with EMS

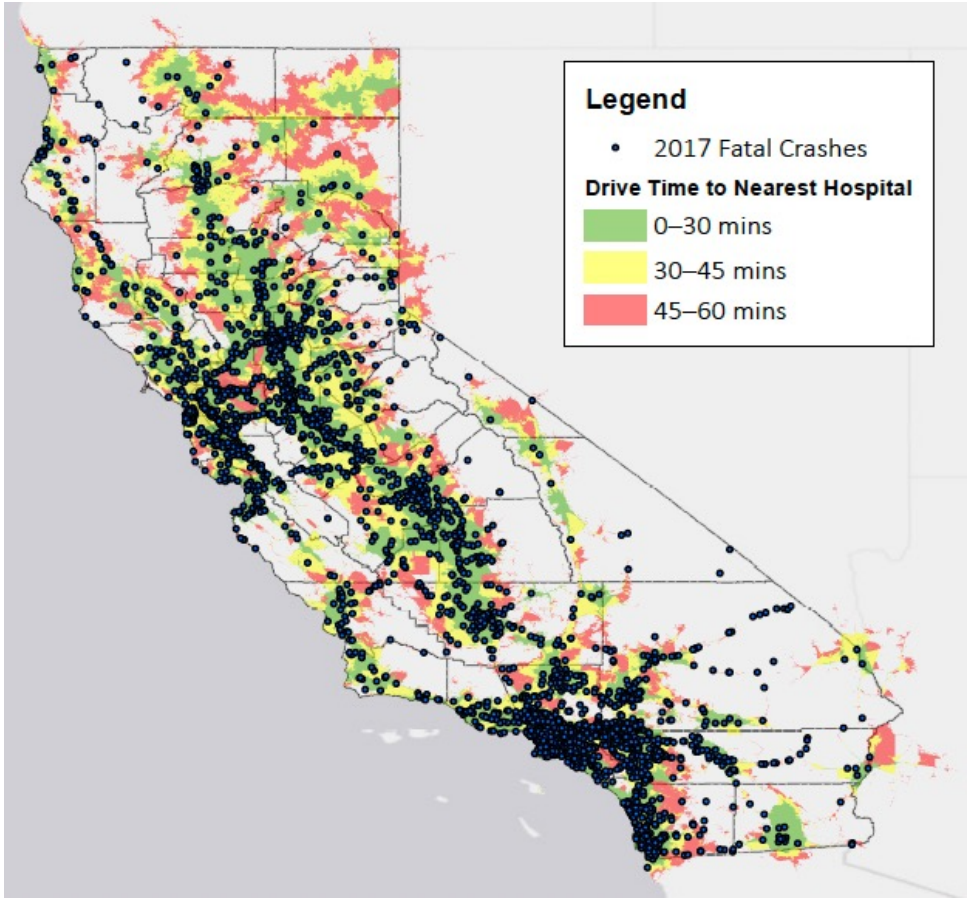


Image Credit: California Strategic Highway Safety Plan

Use Project Evaluation & Strategic Planning

NCHRP 1036 Roadway Reallocation Guidance

Looking Forward

06

Change Traffic Safety Culture

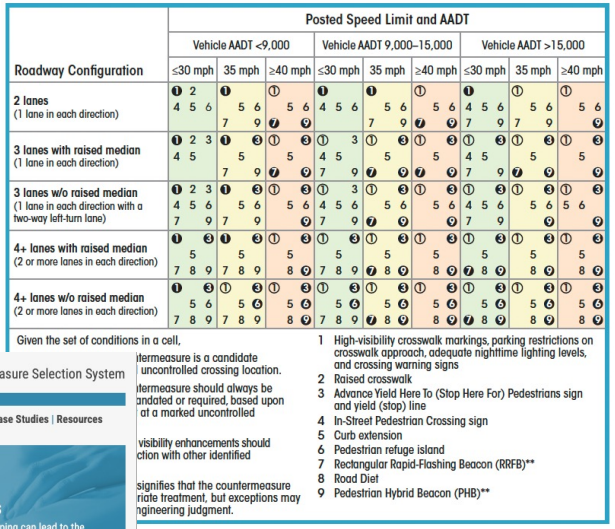
Photo credits: Bob Schneider

FAMILIES FOR SAFE STREETS

We can make different choices to experience different future outcomes.

Pedestrian & Bicyclist Safety Resources

- 2005 Zegeer Marked Crosswalk Study
- FHWA Safe Transportation for Every Pedestrian (STEP)
- NCHRP 926
- NHTSA “Countermeasures that Work”
- NCHRP Synthesis 535
- FHWA PEDSAFE / BIKESAFE
- Vision Zero Network



Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	❶ 2 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6 7 9	① 5 6 7 9	① 5 6 ❾
3 lanes with raised median (1 lane in each direction)	❶ 2 3 4 5	❶ ❸ 5 7 9	① ❸ 5 ❼ ❾	① 3 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❼ ❾	① ❸ 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❾
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	❶ 2 3 4 5 6 7 9	❶ ❸ 5 6 7 9	① ❸ 5 6 ❾	① 3 4 5 6 7 9	① ❸ 5 6 ❼ ❾	① ❸ 5 6 ❾	① ❸ 4 5 6 7 9	① ❸ 5 6 ❾	① ❸ 5 6 ❾
4+ lanes with raised median (2 or more lanes in each direction)	❶ ❸ 5 7 8 9	❶ ❸ 5 7 8 9	① ❸ 5 8 ❾	① ❸ 5 7 8 9	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 7 8 ❾	① ❸ 5 8 ❾	① ❸ 5 8 ❾
4+ lanes w/o raised median (2 or more lanes in each direction)	❶ ❸ 5 6 7 8 9	① ❸ 5 6 7 8 9	① ❸ 5 6 8 ❾	① ❸ 5 6 7 8 9	① ❸ 5 6 ❼ 8 ❾	① ❸ 5 6 8 ❾	① ❸ 5 6 ❼ 8 ❾	① ❸ 5 6 8 ❾	① ❸ 5 6 8 ❾

Given the set of conditions in a cell,
- ...termeasure is a candidate
- ...uncontrolled crossing location.
- ...termeasure should always be
- ...ndated or required, based upon
- ...at a marked uncontrolled
- ...visibility enhancements should
- ...ction with other identified
- ...signifies that the countermeasure
- ...riate treatment, but exceptions may
- ...ngineering judgment.

1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2 Raised crosswalk
3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4 In-Street Pedestrian Crossing sign
5 Curb extension
6 Pedestrian refuge island
7 Rectangular Rapid-Flashing Beacon (RRFB)**
8 Road Diet
9 Pedestrian Hybrid Beacon (PHB)**

Image Credits: FHWA

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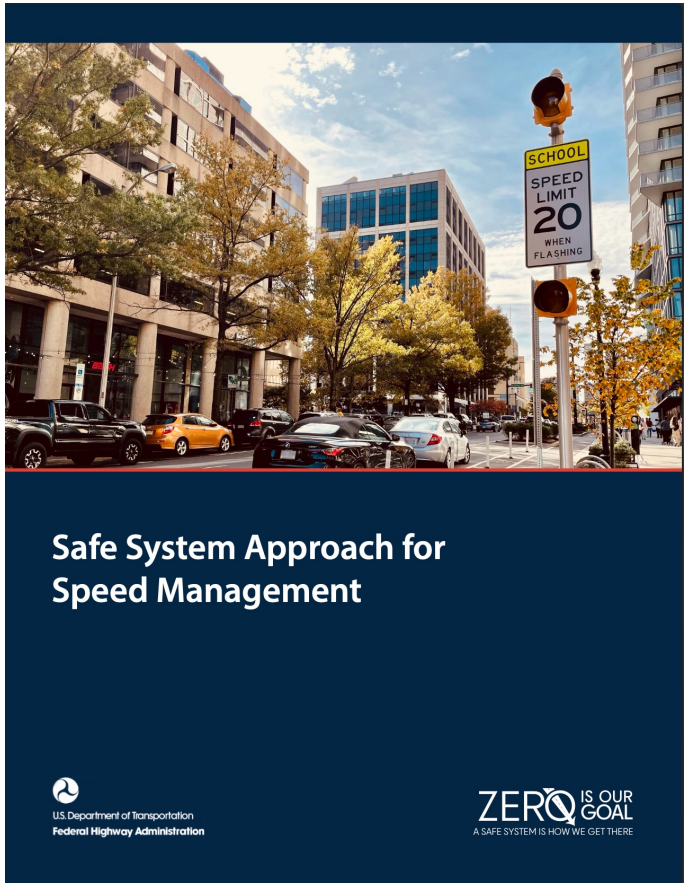
Safe System Resources

- Safe System Approach for Speed Management
- Safe System Project-Based Alignment Tool
- Safe System Policy-Based Alignment Tool
- Primer on Safe System Approach for Pedestrians and Bicyclists
- Safe System Roadway Design Hierarchy
- Safe System Based Framework and Analytical Methodology for Assessing Intersections
- Integrating the Safe System Approach with the Highway Safety Improvement Program



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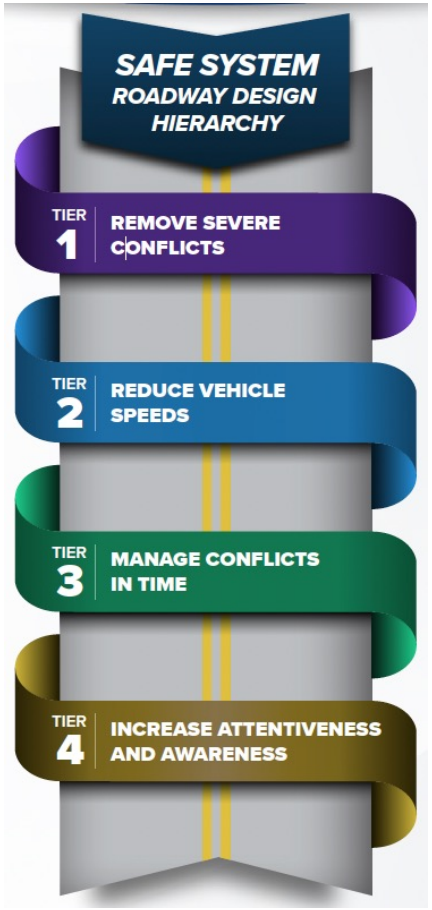
Safe System Roadway Design Hierarchy



Proven Safety Countermeasure	Tier 1 Remove Severe Conflicts	Tier 2 Reduce Vehicle Speeds	Tier 3 Manage Conflicts in Time	Tier 4 Increase Attentiveness and Awareness
Speed Management				
Appropriate Speed Limits for All Road Users		✓		
Speed Safety Cameras		✓		
Variable Speed Limits		✓		✓
Pedestrian/Bicyclist				
Bicycle Lanes	✓			
Crosswalk Visibility Enhancements				✓
Leading Pedestrian Interval			✓	
Medians and Pedestrian Refuge Islands	✓	✓		
Pedestrian Hybrid Beacons			✓	
Rectangular Flashing Beacons (RRFB)				✓
Road Diets	✓	✓		
Walkways	✓			
Roadway Departure				
Enhanced Delineation for Horizontal Curves				✓
Longitudinal Rumble Strips and Stripes				✓
Median Barriers	✓			

Image Credits: FHWA

Inspiring Urban and Suburban Examples

Insights from Australasia

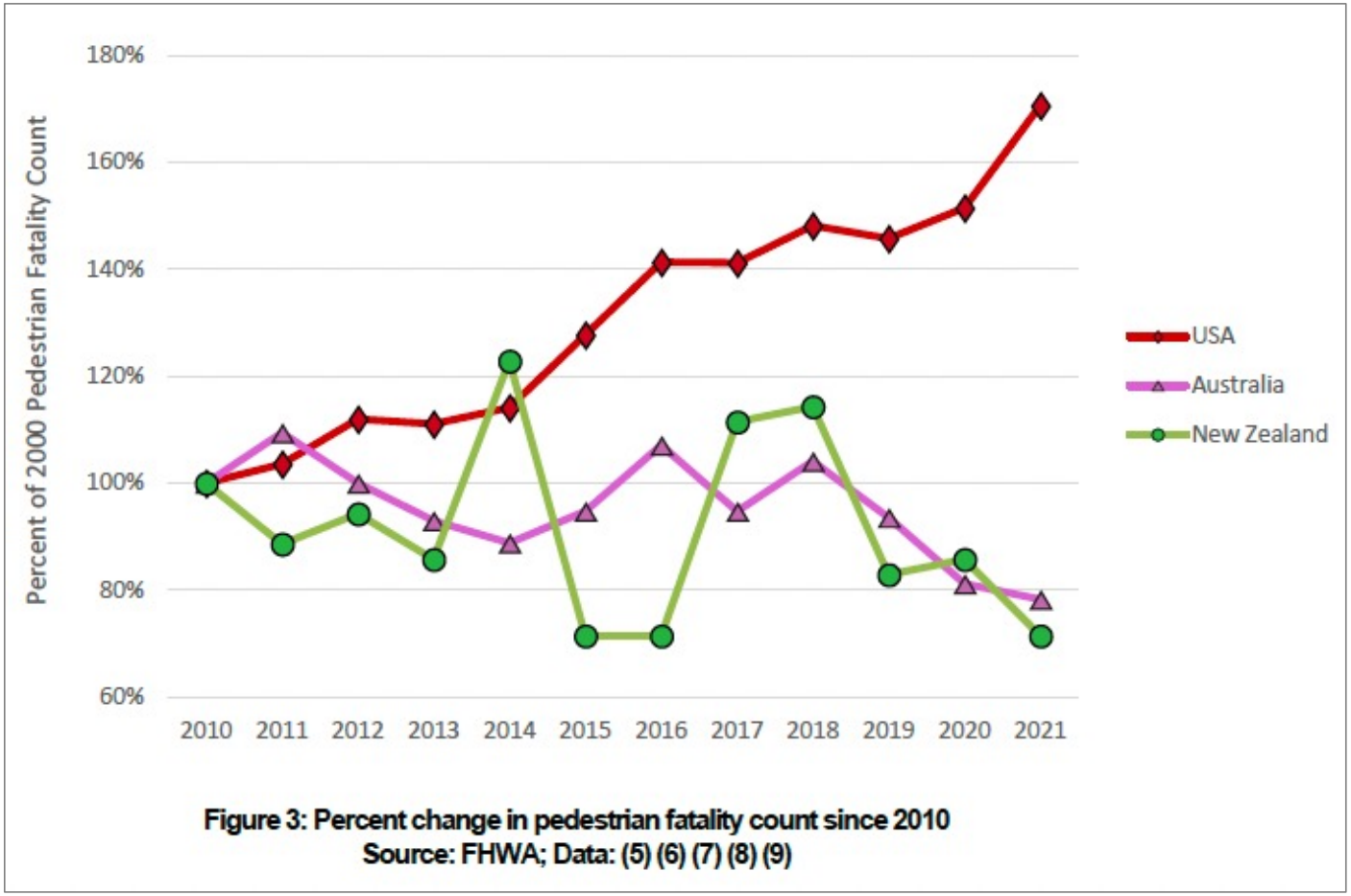


Figure 3: Percent change in pedestrian fatality count since 2010
Source: FHWA; Data: (5) (6) (7) (8) (9)

Image Credit: FHWA

Insights from Australasia

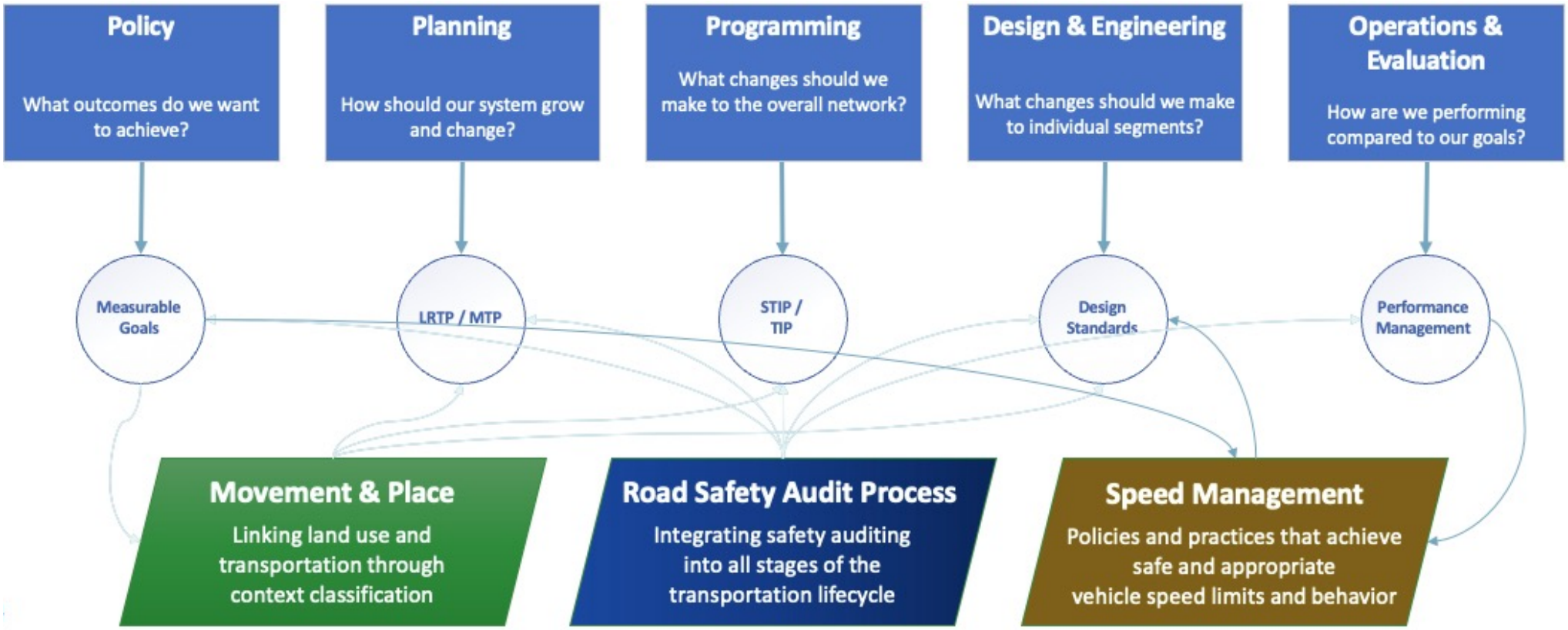


Image Credit: FHWA

Insights from Australasia

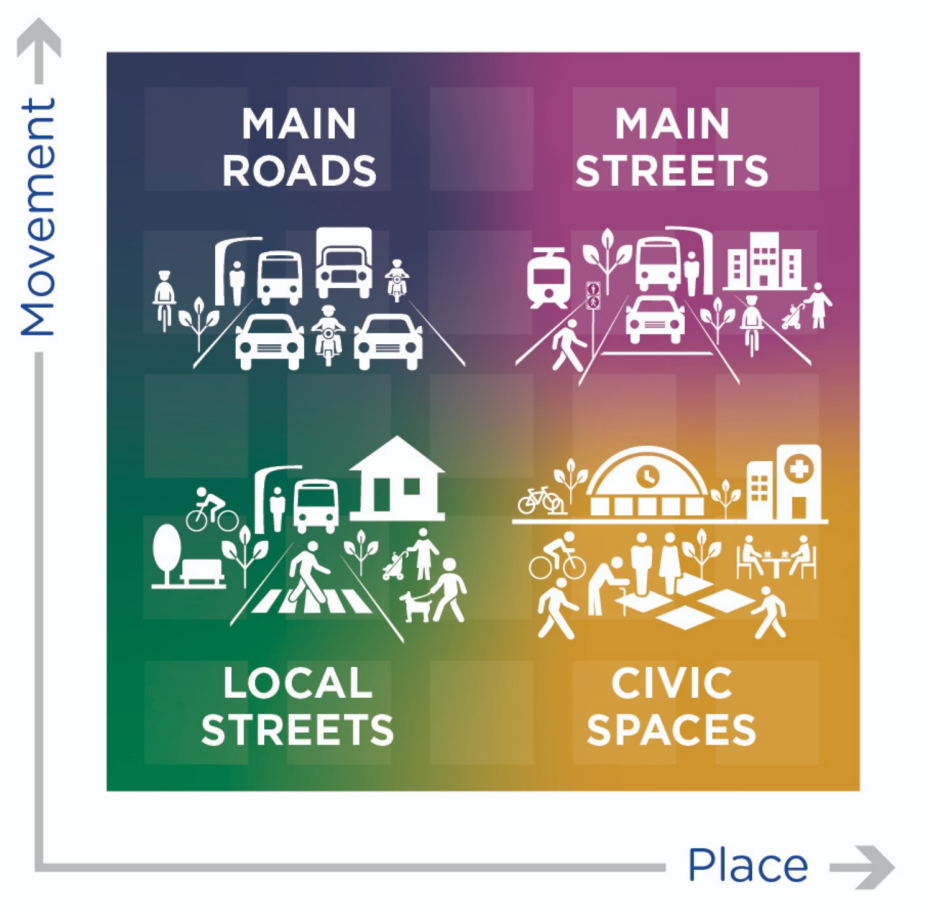


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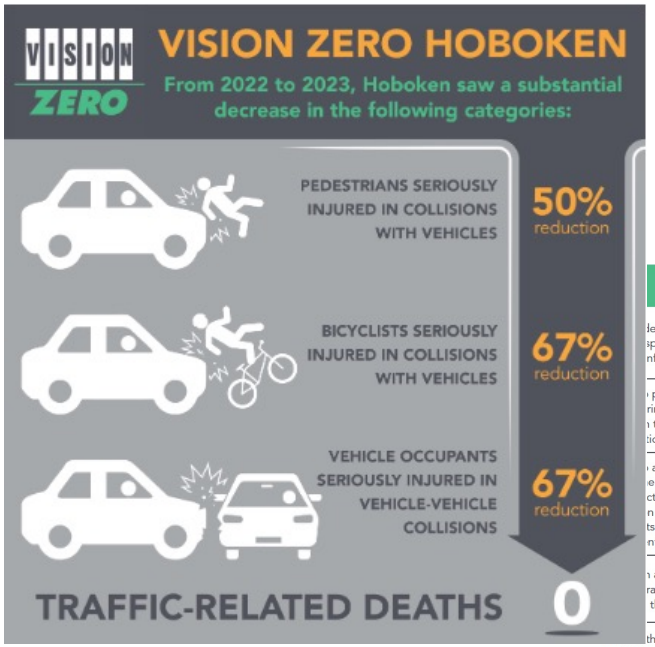
Image Credit: Transport for New South Wales

Hoboken, New Jersey



	Action	Timeframe	Lead to Completion	Primary Support	Additional Support	Performar
	dedicated expenditure line within sportation operating budget for nfrastructure.	Immediately	Department of Transportation and Parking	Hoboken City Council		Bicycle infrastruc line created with budget in 2021.
	policy thresholds to initiate an ring study for safety with guidance to consider specific roadway or ion modifications.	Immediately	City Engineer's Office	Hoboken Housing Authority		Adopted policy t
	a Traffic Calming Master Plan to e installation of traffic calming cture. Focus on installing speed- n infrastructure along high crash ts where excessive speed is a nt crash factor.	Immediately	Department of Transportation and Parking	City Engineer's Office	Hoboken Police Department	Traffic calming pl programmed for locations within publication of Vi Plan.
	a permanent funding source for ram and align existing funding through joint budget requests.	Within two years	Mayor's Office	Department of Transportation and Parking		Dedicated fundi
SS13	the definition of the roadway curbside zone to protect non-vehicular users and describe how the zone may be used to serve non-automotive uses.	Within two years	Department of Transportation and Parking	Police Department	Department of Community Development	New Policy Adopted.
SS22	Update planned capital improvement program to consider high crash corridors.	Within two years	Department of Transportation and Parking	Hudson County		Number of funded projects on the High Injury Network, high crash locations, and in communities of concern using revised prioritization scheme.
SS20	Implement Complete Street Design Guide recommendations for priority intersections, gateway streets, and Special Focus streets.	Within five years	Department of Transportation and Parking	Hudson County	Hoboken Police Department	City shall provide annual assessments on its progress towards full implementation of the Complete Street Design Guide recommendations.

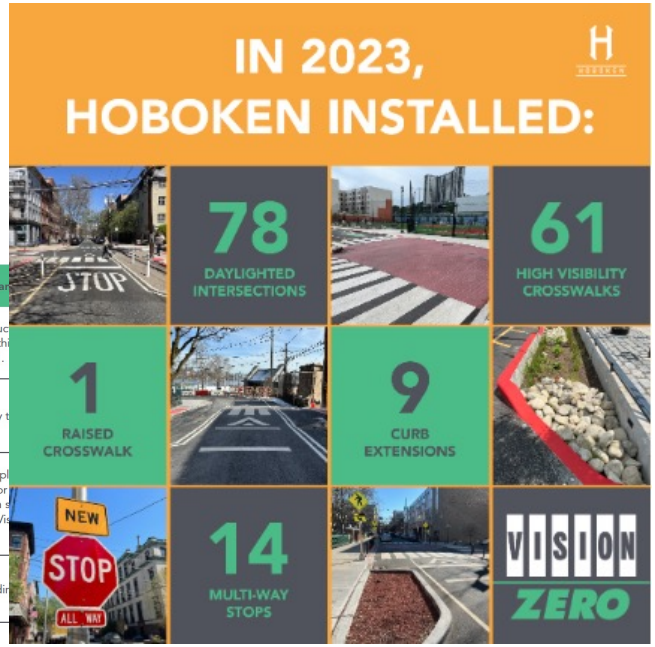


Image Credits: City of Hoboken, NJ

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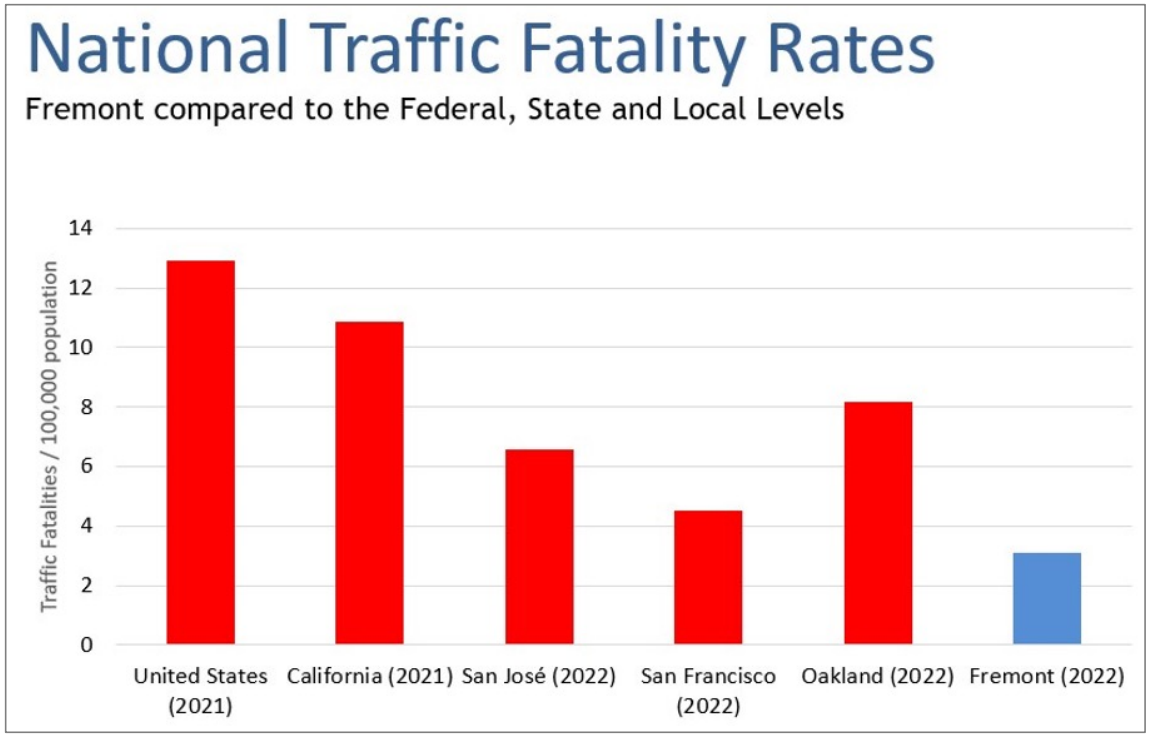
Fremont, California



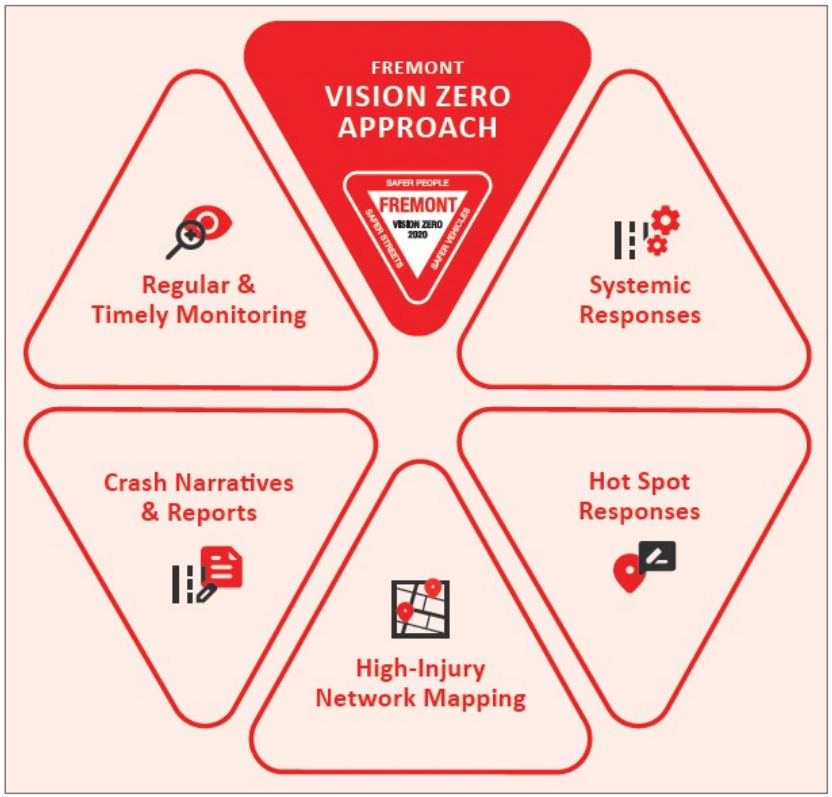


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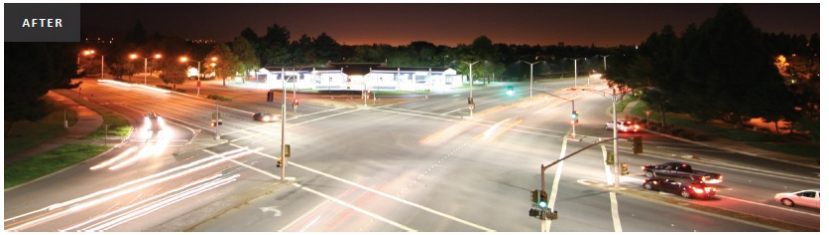
Image Credits: City of Fremont, CA

Fremont, California

Photo Credits: City of Fremont, CA

- Quick-build projects
- Speed reduction
- Bicycle protection
- Improved lighting
- Improved crossings



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Austin, Texas

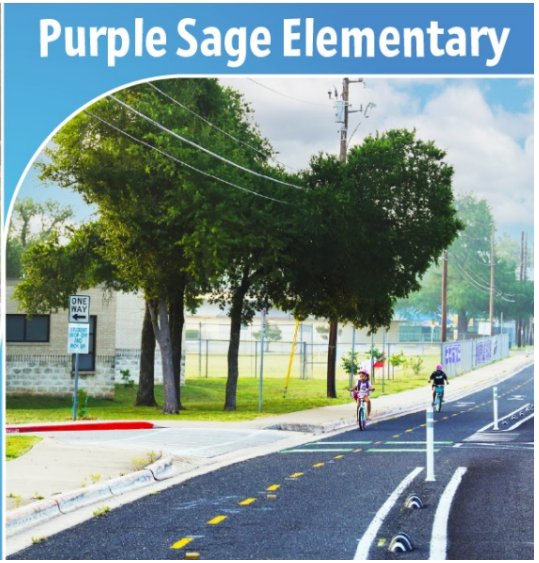

Image Credits: Austin Department of Transportation

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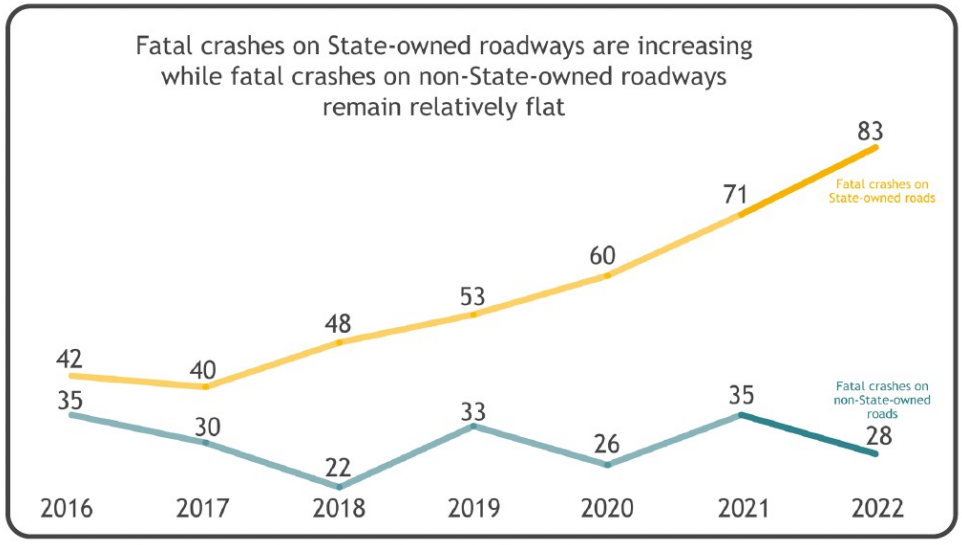

Inspiring Rural Example

Improving Pedestrian Safety in Louisiana

- Working through cooperative extension program & land grant universities (TTI!)
- Reduced local cash match for Transportation Alternatives funding
- Encourage people to take advantage of national resources
  - Safe Routes Partnership
  - CDC Division of Nutrition, Physical Activity, and Obesity (DNPAO)
  - National Center for Rural Road Safety
- Rural Safety Summit
  - Elected official
  - Youth in walk audits

Image Credit: Louisiana State Ag Center

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Questions?

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