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

U.S. Department of Transportation
Federal Highway Administration

# Pavement Friction: Where the Rubber Hits the Road...Safely

USDOT Federal Highway Administration

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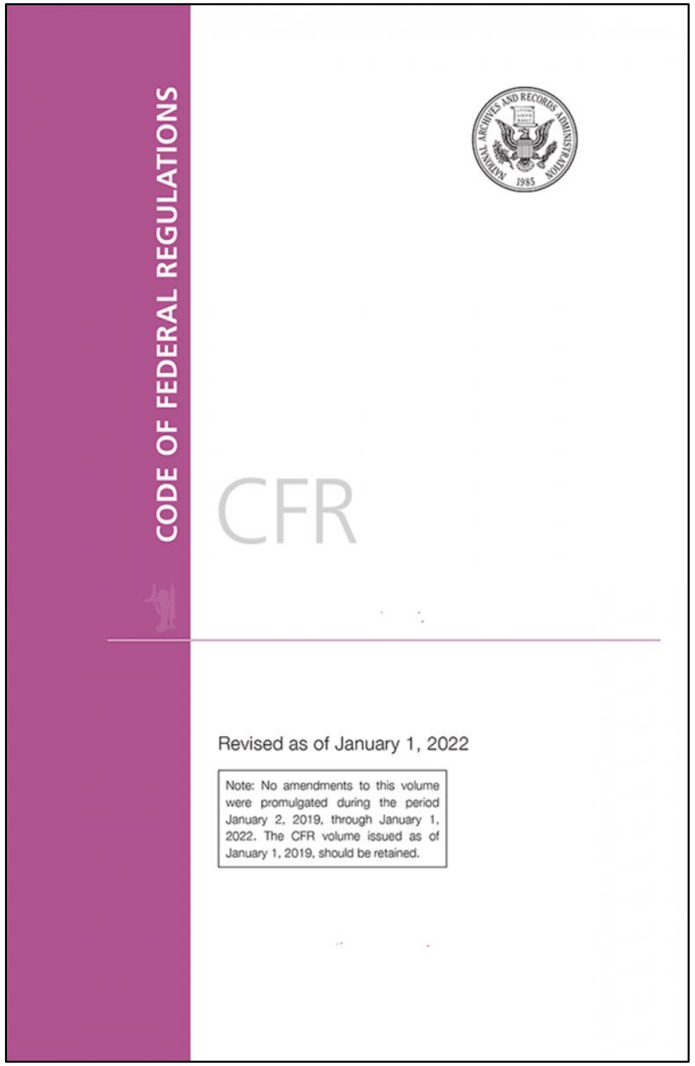
# 23 CFR Part 626




**Source:** U.S. Government Printing Office

## §626.3 Pavement Design Policy

Pavement shall be designed to accommodate current and predicted traffic needs in a safe, durable, and cost-effective manner.

# Scale of the Road Safety Challenge

A public health crisis on our roadways, but gradual progress in recent years:

| Estimates of Motor Vehicle Traffic Fatalities, 2021-2023 | | | |
|---|---|---|---|
| 2021 Estimates | 2022 Estimates | 2023 Estimates | **Percent Decrease** from 2021 to 2023 |
| 43,230 | 42,514 | 40,990 | **5.2%** |

Source: *Fatality Analysis Reporting System (FARS), National Highway Traffic Safety Administration (NHTSA)*

# The New Safety Paradigm

## The Safe System Approach: 6 Core Principles

- Death/Serious Injury is Unacceptable
- Humans Make Mistakes
- Humans are Vulnerable
- Responsibility is Shared
- Safety is Proactive
- Redundancy is Crucial


Source: FHWA

5 Inter-Related Elements

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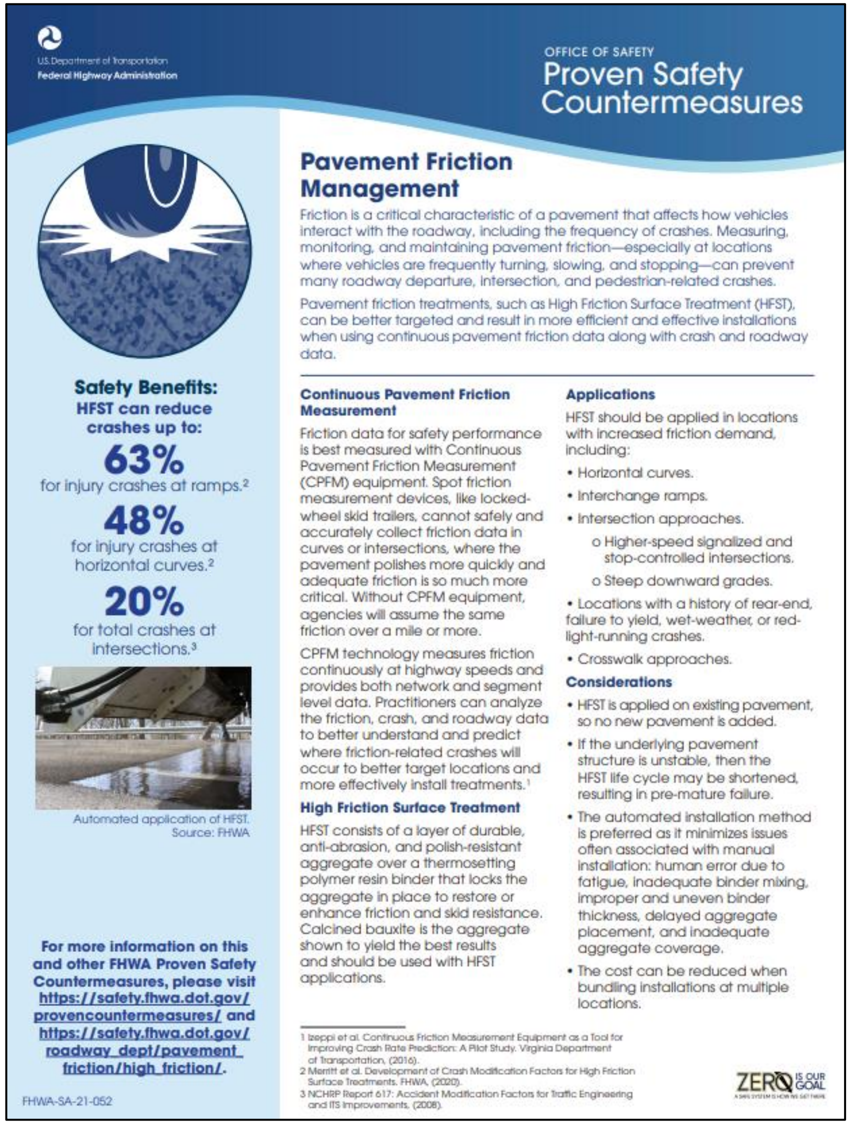
# A New Direction

The Safe System approach aims to eliminate fatal and serious injuries for all road users by:

**Accommodating human mistakes**

**Keeping impacts on the human body at tolerable levels**

# An “Invisible” PSC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OFFICE OF SAFETY
Proven Safety Countermeasures

## Pavement Friction Management

Friction is a critical characteristic of a pavement that affects how vehicles interact with the roadway, including the frequency of crashes. Measuring, monitoring, and maintaining pavement friction—especially at locations where vehicles are frequently turning, slowing, and stopping—can prevent many roadway departure, intersection, and pedestrian-related crashes.

Pavement friction treatments, such as High Friction Surface Treatment (HFST), can be better targeted and result in more efficient and effective installations when using continuous pavement friction data along with crash and roadway data.

**Safety Benefits:**
**HFST can reduce crashes up to:**

**63%** for injury crashes at ramps.[2]

**48%** for injury crashes at horizontal curves.[2]

**20%** for total crashes at intersections.[3]

Automated application of HFST.
Source: FHWA

**Continuous Pavement Friction Measurement**

Friction data for safety performance is best measured with Continuous Pavement Friction Measurement (CPFM) equipment. Spot friction measurement devices, like locked-wheel skid trailers, cannot safely and accurately collect friction data in curves or intersections, where the pavement polishes more quickly and adequate friction is so much more critical. Without CPFM equipment, agencies will assume the same friction over a mile or more.

CPFM technology measures friction continuously at highway speeds and provides both network and segment level data. Practitioners can analyze the friction, crash, and roadway data to better understand and predict where friction-related crashes will occur to better target locations and more effectively install treatments.[1]

**High Friction Surface Treatment**

HFST consists of a layer of durable, anti-abrasion, and polish-resistant aggregate over a thermosetting polymer resin binder that locks the aggregate in place to restore or enhance friction and skid resistance. Calcined bauxite is the aggregate shown to yield the best results and should be used with HFST applications.

**Applications**

HFST should be applied in locations with increased friction demand, including:

- Horizontal curves.
- Interchange ramps.
- Intersection approaches.
  - o Higher-speed signalized and stop-controlled intersections.
  - o Steep downward grades.
- Locations with a history of rear-end, failure to yield, wet-weather, or red-light-running crashes.
- Crosswalk approaches.

**Considerations**

- HFST is applied on existing pavement, so no new pavement is added.
- If the underlying pavement structure is unstable, then the HFST life cycle may be shortened, resulting in pre-mature failure.
- The automated installation method is preferred as it minimizes issues often associated with manual installation: human error due to fatigue, inadequate binder mixing, improper and uneven binder thickness, delayed aggregate placement, and inadequate aggregate coverage.
- The cost can be reduced when bundling installations at multiple locations.

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/high_friction/.**

1 Izeppi et al. Continuous Friction Measurement Equipment as a Tool for Improving Crash Rate Prediction: A Pilot Study. Virginia Department of Transportation, (2016).
2 Merritt et al. Development of Crash Modification Factors for High Friction Surface Treatments. FHWA, (2020).
3 NCHRP Report 617: Accident Modification Factors for Traffic Engineering and ITS Improvements. (2008).

FHWA-SA-21-052

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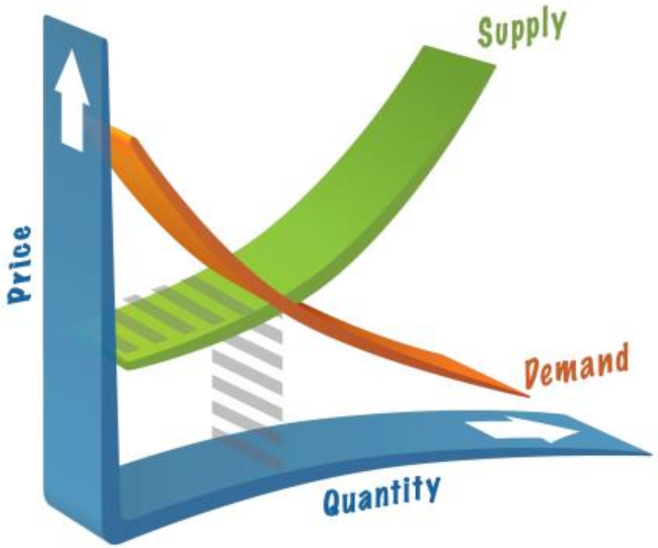
- Originally High Friction Surface Treatment (HFST)
- 2021 PSC Update expanded this to be the foundation of Pavement Friction Management
  - Still includes HFST
  - Added Continuous Pavement Friction Measurement (CPFM)
  - Recognizes importance of friction at additional locations, i.e., intersections and crosswalk approaches
  - Proactive safety approach that dovetails with pavement preservation and asset management

**Source:** FHWA [Pavement Friction Management | FHWA (dot.gov)]

# Pavement Friction Characteristics

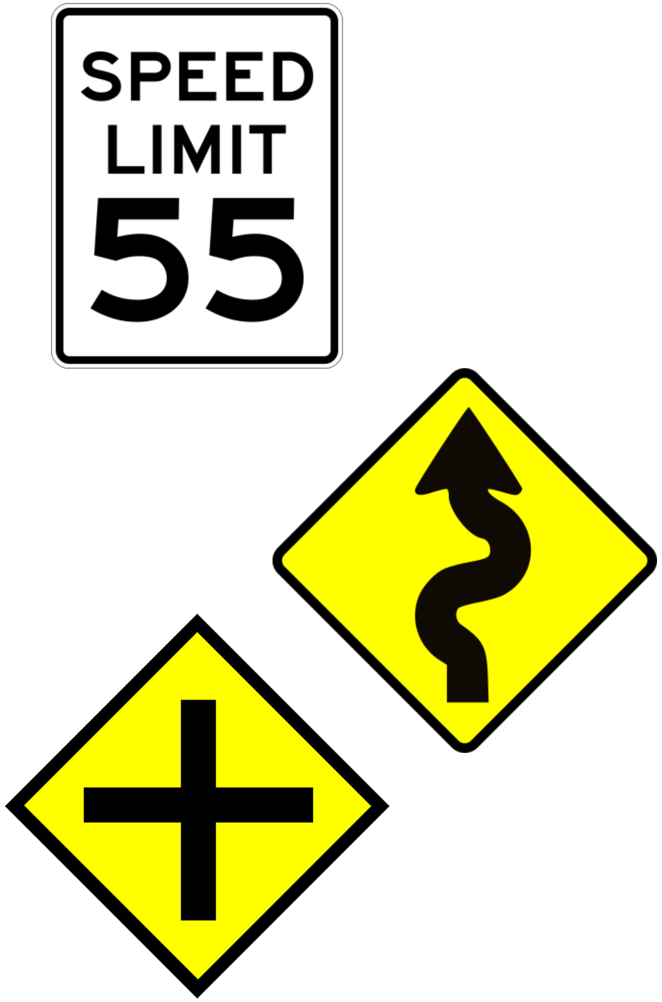
- Friction (overall) is a function of two pavement surface characteristics: *micro*texture and *macro*texture.
- Pavement Friction Design Objective:
  - Design for end-of-life friction meeting road friction demand.
  - Different roads, and points along roads, have different friction demand.
- Friction demand is the level of friction needed to safely perform (i.e., meet driver expectations) for braking/stopping, steering/turning, and accel/decel.
  - Friction demand varies based on type of maneuver.
  - The nature of friction demand changes with speed.



# Back...to the Future!

## NCHRP Report 37 (1967):

*"...because the intensity of the polishing process increases markedly with tread element slip, all other factors being equal, the lowest friction levels are found on high-speed roads, curves, and approaches to intersections; in short, in locations at which high friction values are needed most."*



# Field Friction Measurement

Conventional Friction Tester used on U.S. roads

- Locked-Wheel Skid Trailer (LWST)
- Runs at 40MPH for a 60-foot test (usually with ribbed tire)
- High-quality, repeatable test that provides sensible, reproducible results
- ***BUT…***even when done at network level (recurring intervals) this is sample-based testing

**Source:** Center for Sustainable Transportation Infrastructure (CSTI) at Virginia Tech Transportation Institute (VTTI).

# Network Testing: Continuous vs. Sample

- Where routine pavement friction testing is still done in the U.S., it is sample-based using LWST.
- How does this compare to other pavement asset management data collection methods?
  - Density (Intelligent Compaction, Infrared Technology, Ground Penetrating Radar (GPR)).
  - Structural Integrity (Traffic Speed Deflectometer (TSD), GPR).
  - Segregation (Texture).
  - Ride/smoothness.
  - Rutting and cracking.

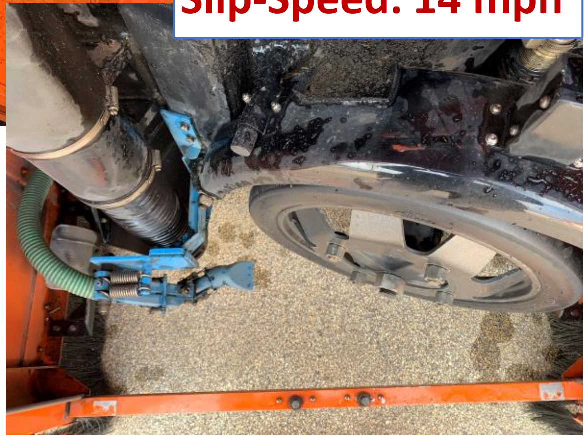
**Source:** FHWA

***Do pavement conditions vary markedly as you travel down the road???***

# Continuous Friction Measurement


**Source:** Center for Sustainable Transportation Infrastructure (CSTI) at Virginia Tech Transportation Institute (VTTI).


**Source:** FHWA.

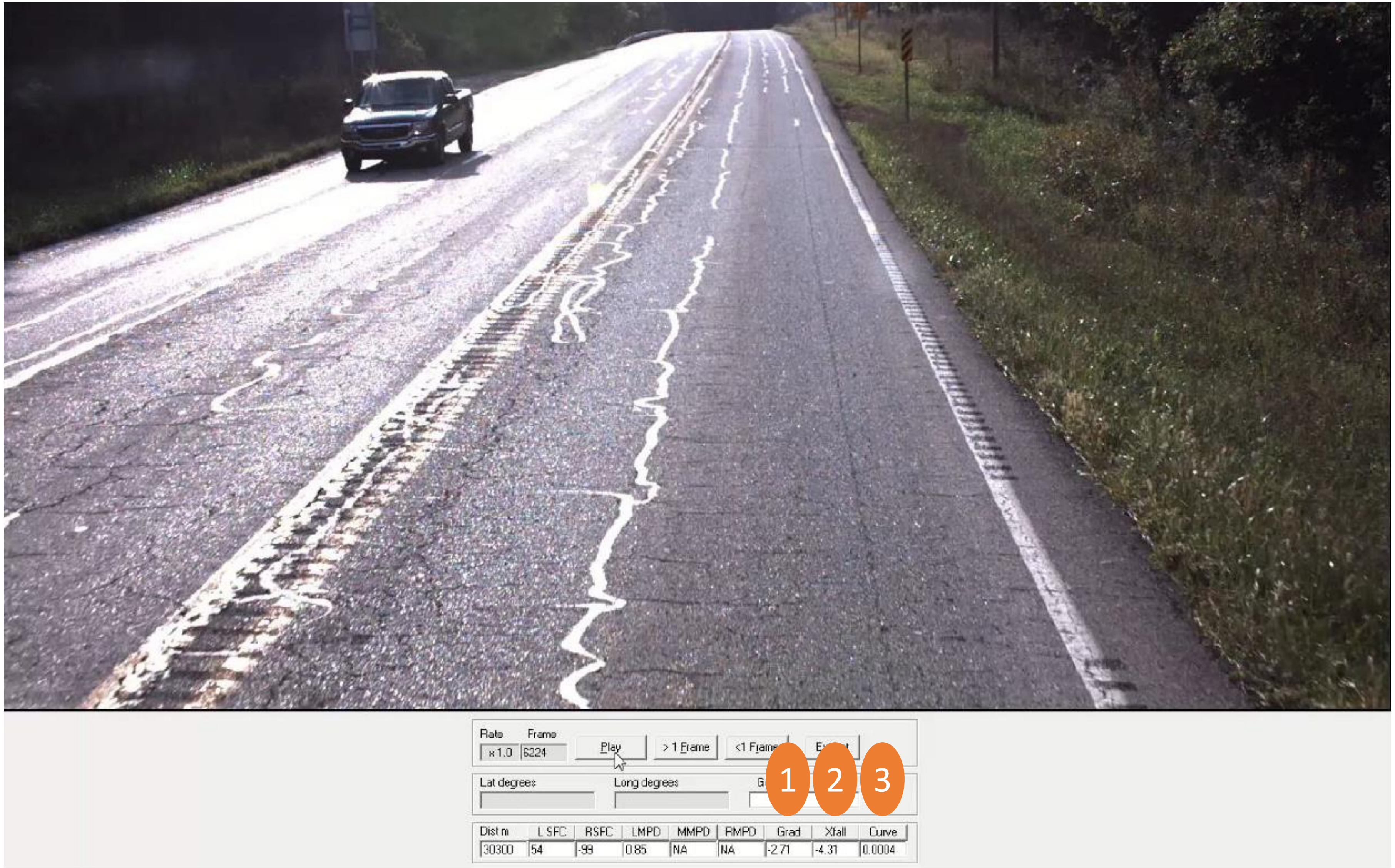



**Source:** FHWA.

## Sideway-force Coefficient Routine Investigation Machine (SCRIM)

- Rubber Tire test continuously measuring every foot of pavement (more sensitive to microtexture).
- Laser based texture measurement system measuring every foot of pavement (macrotexture).

# Additional Data Collection Ability

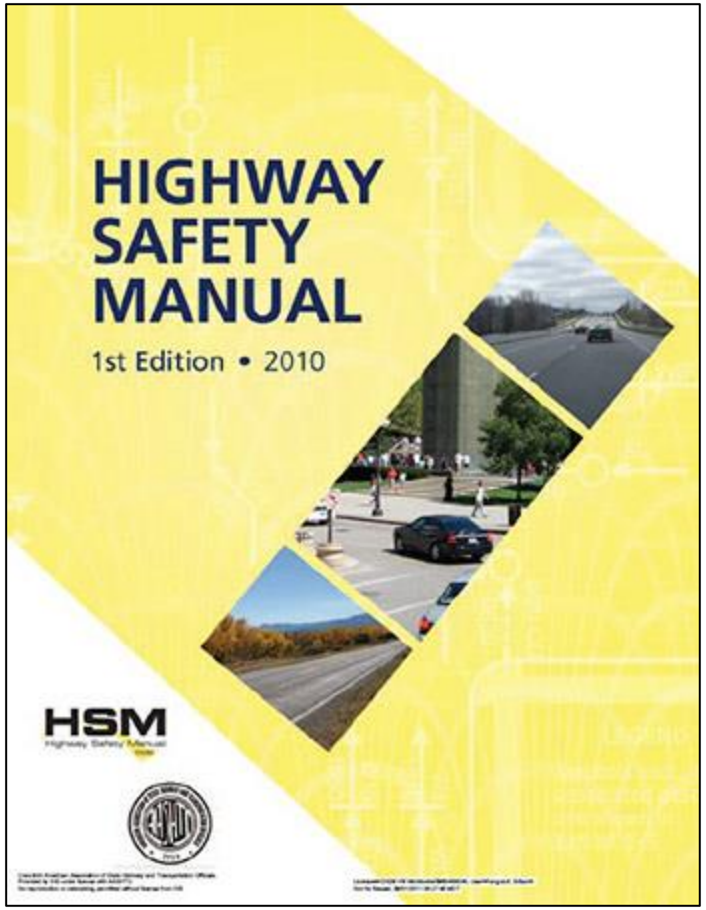



SCRIM also collects:

1. Grade
2. Cross-slope
3. Curvature

# Network Screening

- Method that objectively considers the following factors and how they may contribute to future crashes:
  - Crash history.
  - Roadway factors.
  - Traffic characteristics.
- Helps agencies identify and prioritize locations for potential safety investment.



# Modeling Friction and Safety

- CPFM data from 5 states (FL, ND, TX, VA, WA)
- Over 50K 0.1-mile segments and 160K crashes across freeways, rural multilane hwys, rural two-lane hwys, and urban arterials; by tangent, curve, or intersection

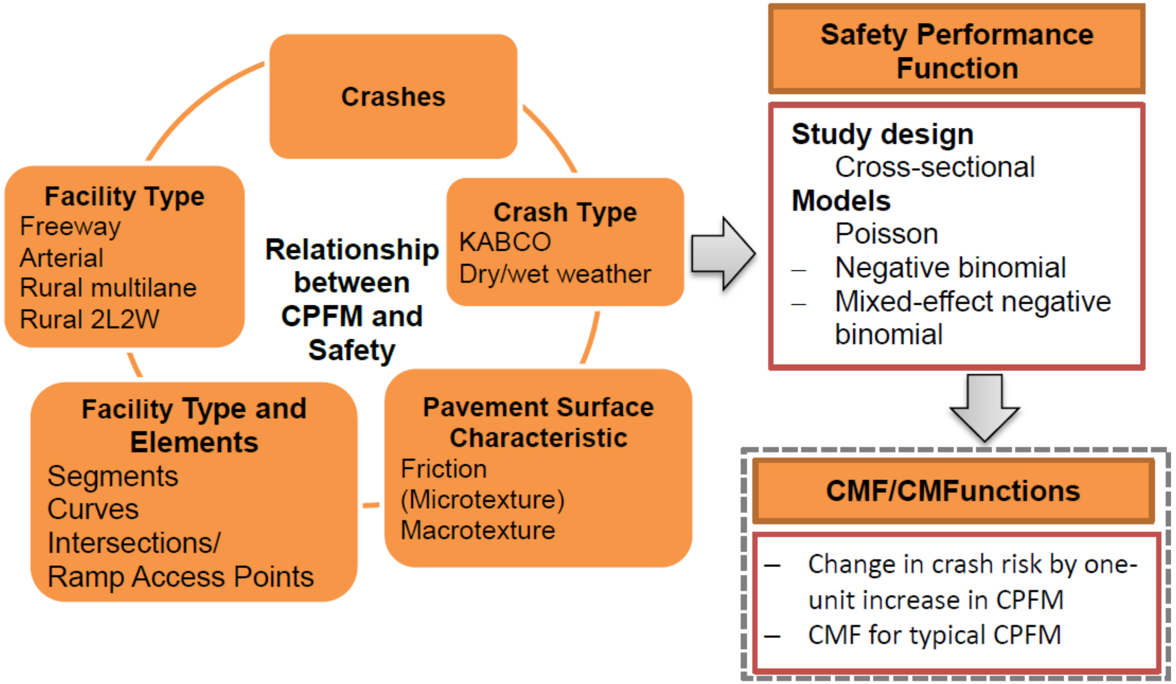
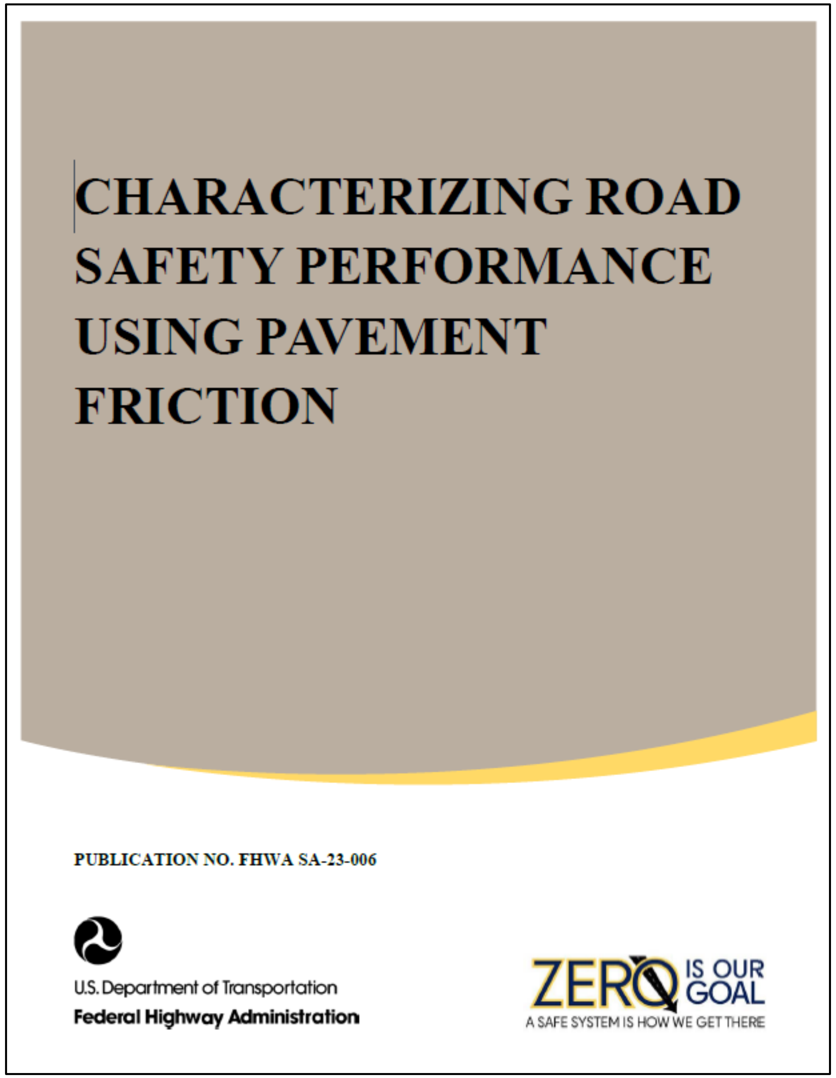



Figure 1. Illustration. Analysis framework (Source: CSTI/Arora and Associates, P.C.).




FHWA Characterizing Road Safety Performance Using Pavement Friction | FHWA

# Friction and Safety Performance

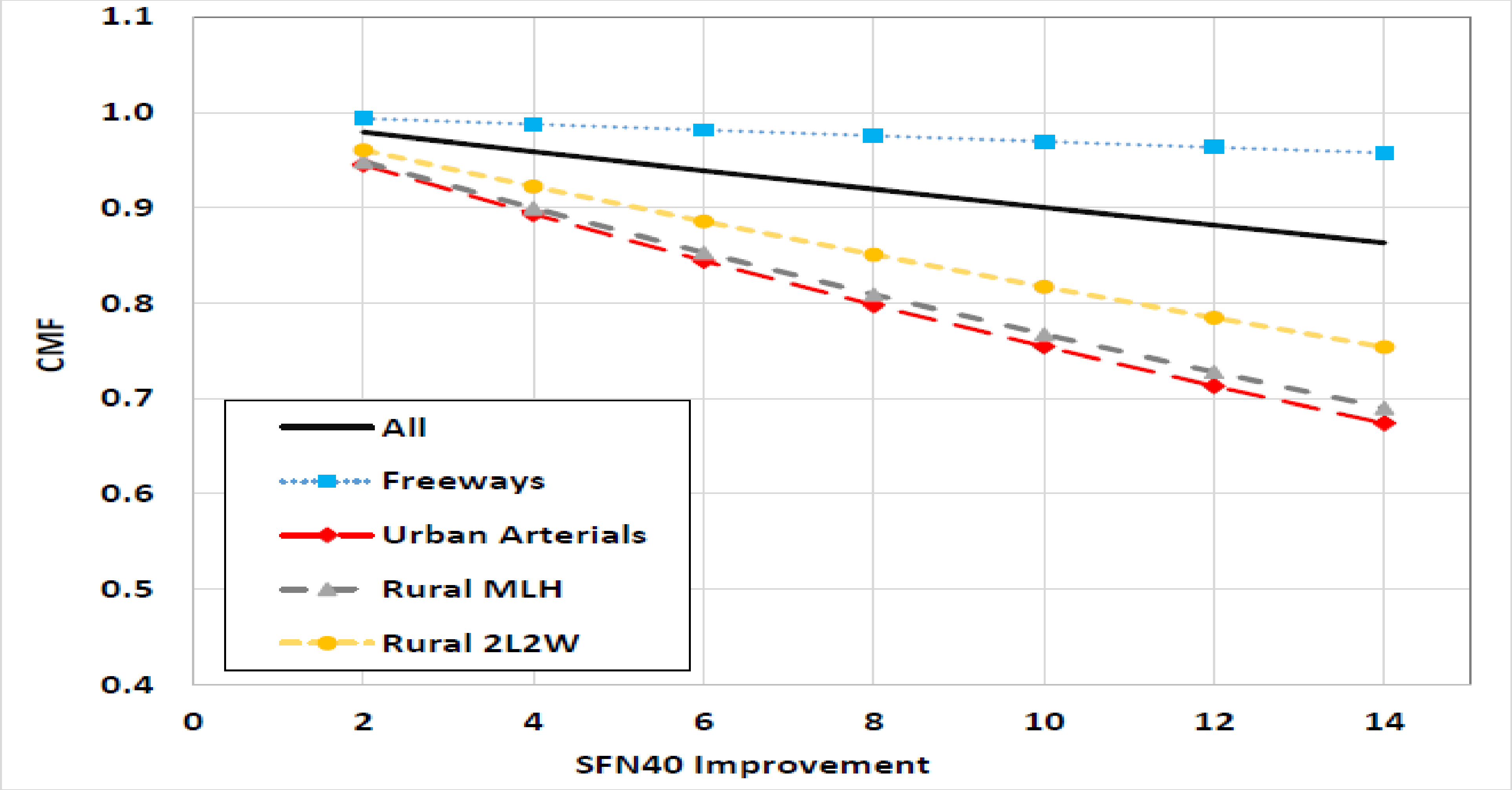



Figure 3. Graph. Comparison of CMFx for friction on different roadway facility types (Source: FHWA).

# Friction and Safety Performance

**Table 10. CMF and percent crash reduction for a 10-unit increase in SFN40.[1,2]**

| Roadway Facility | Site Type | CMFx regression coefficient ($\beta_1$) | CMF for 10-Unit SFN40 Increase | Standard Error (CMF) | % Crash Reduction |
|---|---|---|---|---|---|
| All Facilities | All Site Types | -0.0105 | 0.901 | 0.0064 | 9.9 |
| Freeways | All Freeways Site Types | -0.0031 | 0.969 | 0.0093 | 3.1 |
| | Tangent Segments | -0.0023 | 0.977 | 0.0103 | 2.3 |
| | Ramp Access Points | -0.0135 | 0.874 | 0.0219 | 12.6 |
| | Curves | -0.0169 | 0.844 | 0.0611 | 15.6 |
| Urban Arterials | All Urban Arterials Site Types | -0.0282 | 0.754 | 0.0118 | 24.6 |
| | Divided Tangent Segments | -0.0288 | 0.754 | 0.0221 | 25.0 |
| | Undivided Tangent Segments | -0.0230 | 0.794 | 0.0286 | 20.6 |
| | Intersections | -0.0357 | 0.700 | 0.0161 | 30.1 |
| | Curves | -0.0281 | 0.755 | 0.0625 | 24.5 |
| Rural Multilane Highways | All Rural Multilane Highways Site Types | -0.0265 | 0.767 | 0.0142 | 23.3 |
| | Divided Tangent Segments | -0.0168 | 0.846 | 0.0238 | 15.4 |
| | Undivided Tangent Segments | -0.0094 | 0.910 | 0.0318 | 9.0 |
| | Intersections | -0.0344 | 0.709 | 0.0218 | 29.1 |
| | Curves | -0.0187 | 0.829 | 0.0731 | 17.1 |
| Rural – 2-Lane 2-Way Road | All R2L-2W Roads Site Types | -0.0202 | 0.817 | 0.0196 | 18.3 |
| | Tangent Segments | -0.0096 | 0.909 | 0.0243 | 9.1 |
| | Intersections | -0.0188 | 0.829 | 0.0386 | 17.1 |
| | Curves | -0.0188 | 0.829 | 0.0593 | 17.1 |

*[1] The CMF values were obtained using equation (6), with the corresponding regression coefficients for $\beta_1$ provided in this table, and assuming a 10-point increase in SFN40 value.*
*[2] The CMFx and CMF corresponding to the Curve site types were developed based on a relatively small number of segments.*

**Table 11. CMF and percent crash reduction by surface condition for a 10-unit increase in SFN40.[1]**

| Roadway Facility | Surface Condition | CMFx regression coefficient ($\beta_1$) | CMF for 10-unit SFN40 increase (1) | Standard Error CMF | % Crash reduction |
|---|---|---|---|---|---|
| Expressways | Total Wet | -0.0270 | 0.763 | 0.0109 | 23.7 |
| | Total Dry | -0.0135 | 0.873 | 0.0078 | 12.6 |
| Freeways | Total Wet | -0.0088 | 0.916 | 0.0152 | 8.4 |
| | Total Dry | -0.0023 | 0.977 | 0.0106 | 2.3 |
| Urban Arterials | Total Wet | -0.0479 | 0.619 | 0.0198 | 38.1 |
| | Total Dry | -0.0348 | 0.706 | 0.0150 | 29.4 |
| Rural Multilane Highways | Total Wet | -0.0251 | 0.778 | 0.0179 | 22.2 |
| | Total Dry | -0.0251 | 0.778 | 0.0178 | 22.2 |
| Rural 2-lane, 2-way Road | Total Wet | -0.0467 | 0.627 | 0.0575 | 37.3 |
| | Total Dry | -0.0354 | 0.702 | 0.0343 | 29.8 |

# Proposed Facility Type Friction Thresholds

**Table 13. Summary of the threshold analysis**

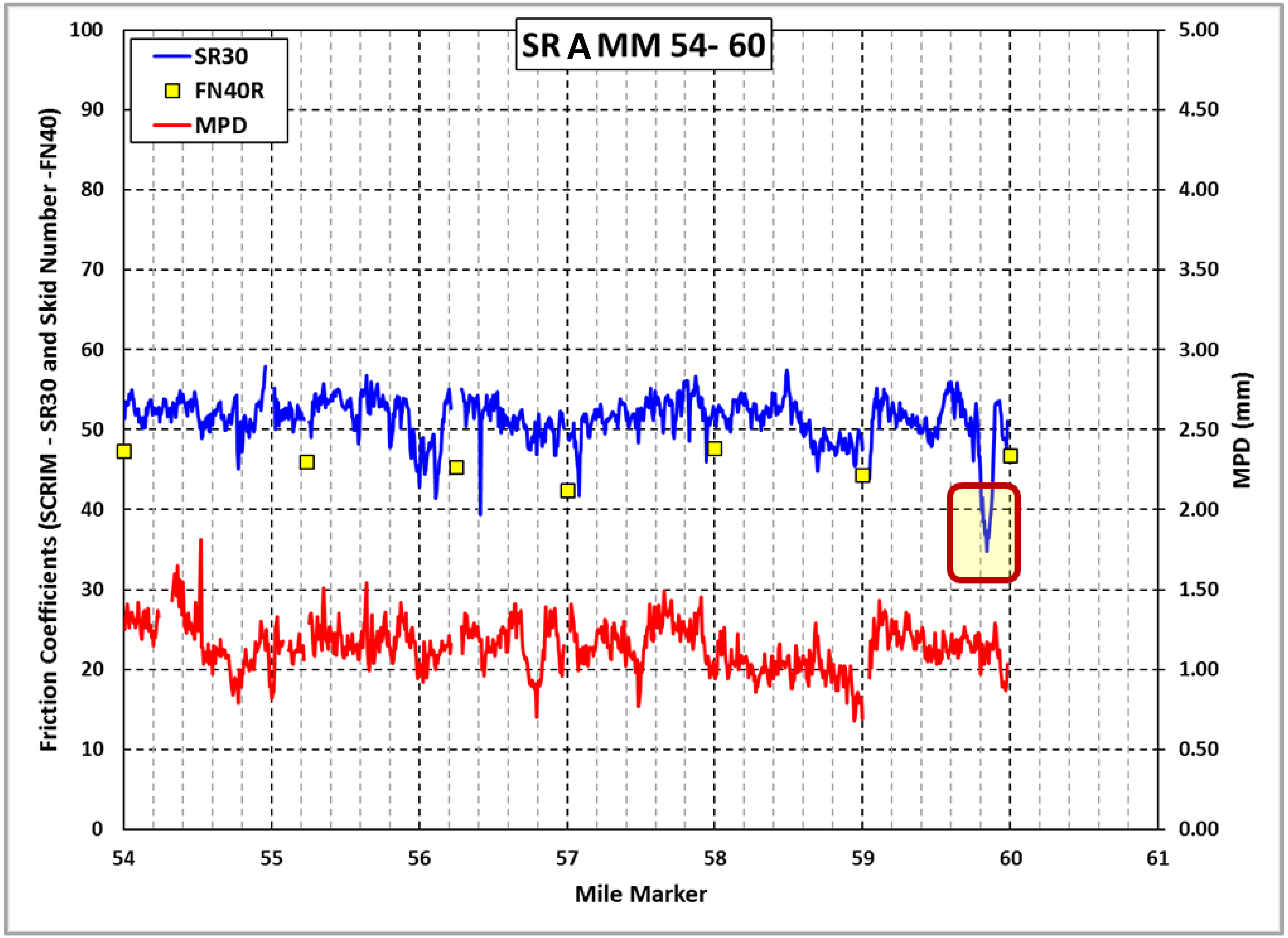
| Roadway Facility Type | Site Type | Suggested | Graphic Threshold | Approximate UK CSC Eq. | CS 228 ST | CS 228 LR |
|---|---|---|---|---|---|---|
| **Freeways** | Tangents | 40 | 36 – 38 | 0.29 - 0.31 | 0.35 | 0.30 |
| | Curves | 45 | 42 – 44 | 0.34 - 0.36 | 0.45 - 0.50 | |
| | Ramp Access | 45 | 44 – 46 | 0.36 - 0.37 | | |
| **Rural Multilane Roadways** | Divided Tangents | 50 | 48 – 50 | 0.39 - 0.41 | 0.35 - 0.40 | 0.30 |
| | Undivided Tangents | 50 | 48 – 50 | 0.39 - 0.41 | 0.40 - 0.45 | 0.35 |
| | Curves | 55 | 54 – 56 | 0.44 - 0.46 | 0.45 - 0.50 | |
| | Intersections | 55 | 54 - 56 | 0.44 - 0.46 | 0.45 - 0.55 | 0.40 |
| **Rural 2-lane, 2-way Roadways** | Tangents | 50 | 48 - 50 | 0.39 - 0.41 | 0.40 - 0.45 | 0.35 |
| | Curves | 55 | 54 - 56 | 0.44 - 0.46 | 0.50- 0.55 | 0.45 |
| | Intersections | 60 | 54 - 56 | 0.44 - 0.46 | 0.45 - 0.55 | 0.40 |
| **Urban and Suburban Arterials** | Divided Tangents | 50 | 48 - 50 | 0.39 - 0.41 | | |
| | Undivided Tangents | 50 | 48 - 50 | 0.39 - 0.41 | | |
| | Curves | 50 | 48 - 50 | 0.39 - 0.41 | | |
| | Intersections | 55 | 54 - 56 | 0.44 - 0.46 | | |

# Value of CPFM for Safety

**Source:** Federal Highway Administration.

- **Relies on crashes (reactive)**
- **25 crashes over past 3 years**
- **High wet-to-dry crash ratio**

# Sample Data vs. Continuous Data

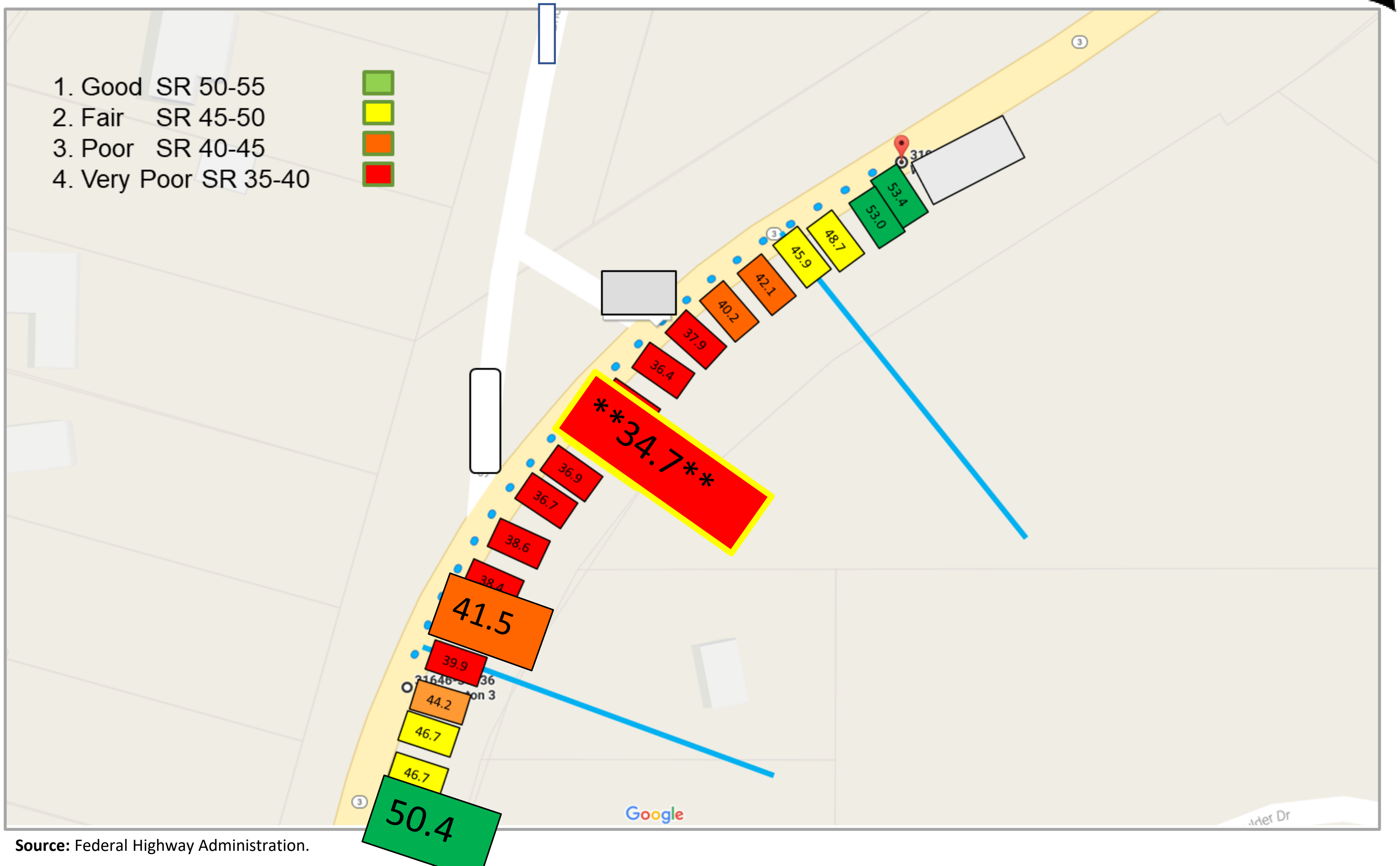



**Source:** Federal Highway Administration.

## Side-by-Side Test Case

- Goal to obtain friction tests at even mile marker intervals
- Blue and red lines are CPFM-SCRIM
  - Blue is microtexture (left axis)
  - Red is macrotexture (right axis)
- Yellow boxes are LWST
  - Note the location deviations at MM55 and MM56
- What about the highlighted area around MM59.8?

# Findings from CPFM




**Source:** Federal Highway Administration.

# Reactive or Proactive?

**Source:** Federal Highway Administration.

- ~~Wait for crashes to happen, i.e., 25 crashes over past 3 years~~
- ~~Trigger a wet-to-dry crash ratio threshold~~
- Friction loss observed via CPFM
- Intervention programmed proactively

# Kentucky Friction Experience

High Friction Surface Treatment (HFST) Program

- Crash reduction across 138 locations
  (107 curves, 30 ramps, 1 intersection)
- In the U.S. very few HFST installations involved sites identified by network friction testing.

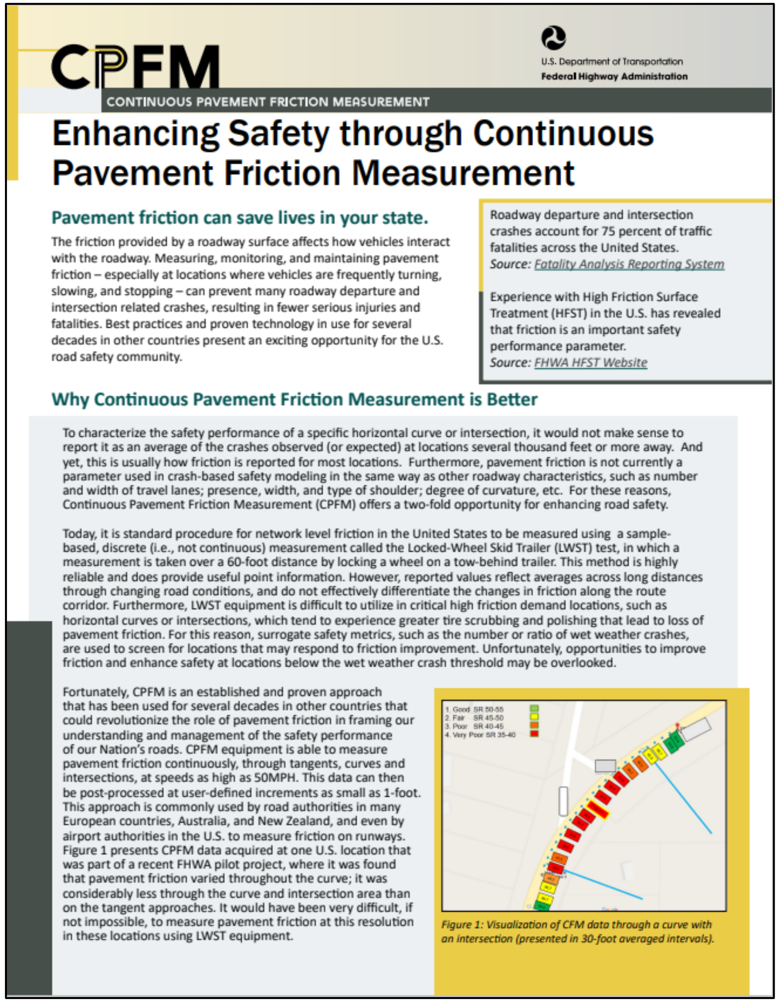
| Crash Reduction from HFST | | |
|---|---|---|
| **Category** | **All** | **Ramps Only** |
| Wet Average | 91% | 90% |
| Dry Average | 53% | 31% |

**Source:** Kentucky Transportation Cabinet (KYTC).

https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/case_studies_noteworthy_prac/kytc/ky_hfst_15_038.pdf

***In 2020, KY initiated largest PFM-CPFM project in the U.S.!***

# For More Information



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CONTINUOUS PAVEMENT FRICTION MEASUREMENT

## Enhancing Safety through Continuous Pavement Friction Measurement

### Pavement friction can save lives in your state.

The friction provided by a roadway surface affects how vehicles interact with the roadway. Measuring, monitoring, and maintaining pavement friction – especially at locations where vehicles are frequently turning, slowing, and stopping – can prevent many roadway departure and intersection related crashes, resulting in fewer serious injuries and fatalities. Best practices and proven technology in use for several decades in other countries present an exciting opportunity for the U.S. road safety community.

Roadway departure and intersection crashes account for 75 percent of traffic fatalities across the United States.
*Source: Fatality Analysis Reporting System*

Experience with High Friction Surface Treatment (HFST) in the U.S. has revealed that friction is an important safety performance parameter.
*Source: FHWA HFST Website*

### Why Continuous Pavement Friction Measurement is Better

To characterize the safety performance of a specific horizontal curve or intersection, it would not make sense to report it as an average of the crashes observed (or expected) at locations several thousand feet or more away. And yet, this is usually how friction is reported for most locations. Furthermore, pavement friction is not currently a parameter used in crash-based safety modeling in the same way as other roadway characteristics, such as number and width of travel lanes; presence, width, and type of shoulder; degree of curvature, etc. For these reasons, Continuous Pavement Friction Measurement (CPFM) offers a two-fold opportunity for enhancing road safety.

Today, it is standard procedure for network level friction in the United States to be measured using a sample-based, discrete (i.e., not continuous) measurement called the Locked-Wheel Skid Trailer (LWST) test, in which a measurement is taken over a 60-foot distance by locking a wheel on a tow-behind trailer. This method is highly reliable and does provide useful point information. However, reported values reflect averages across long distances through changing road conditions, and do not effectively differentiate the changes in friction along the route corridor. Furthermore, LWST equipment is difficult to utilize in critical high friction demand locations, such as horizontal curves or intersections, which tend to experience greater tire scrubbing and polishing that lead to loss of pavement friction. For this reason, surrogate safety metrics, such as the number or ratio of wet weather crashes, are used to screen for locations that may respond to friction improvement. Unfortunately, opportunities to improve friction and enhance safety at locations below the wet weather crash threshold may be overlooked.

Fortunately, CPFM is an established and proven approach that has been used for several decades in other countries that could revolutionize the role of pavement friction in framing our understanding and management of the safety performance of our Nation's roads. CPFM equipment is able to measure pavement friction continuously, through tangents, curves and intersections, at speeds as high as 50MPH. This data can then be post-processed at user-defined increments as small as 1-foot. This approach is commonly used by road authorities in many European countries, Australia, and New Zealand, and even by airport authorities in the U.S. to measure friction on runways. Figure 1 presents CPFM data acquired at one U.S. location that was part of a recent FHWA pilot project, where it was found that pavement friction varied throughout the curve; it was considerably less through the curve and intersection area than on the tangent approaches. It would have been very difficult, if not impossible, to measure pavement friction at this resolution in these locations using LWST equipment.

*Figure 1: Visualization of CFM data through a curve with an intersection (presented in 30-foot averaged intervals).*

### Managing Friction for Safety

More than 50 years ago, National Cooperative Highway Research Program (NCHRP) Report 37 stated that "the lowest friction levels are found on high-speed roads, curves and approaches to intersections; in short, in locations at which high friction values are needed most." Essentially, this research recognized that a clear friction "supply and demand" relationship exists, and is a factor in determining the safety performance of a road. While aggregate testing and specifications, pavement mix designs, and rubber tire manufacturing have evolved in the years since that report was published, the basic friction supply and demand relationship is still relevant. Research conducted in other countries has consistently found a relationship between pavement friction levels and safety, and programs that subsequently established maintenance values for friction that are grounded in safety performance rely upon CPFM for monitoring. Furthermore, pavement friction treatments, including HFST, can be better targeted for installations that are more efficient and effective when using CPFM data.

In 2015, the Federal Highway Administration (FHWA) began collaborating with four State departments of transportation on a pilot study to demonstrate CPFM equipment technologies and compare results to each State's LWST equipment. The study confirmed that CPFM data, combined with crash data, provides significant insight regarding whether friction improvements reduce crashes. Based on the pilot results, FHWA encourages the use of CPFM to provide comprehensive pavement friction data, combined with existing safety data and analysis, to create an overall pavement friction management program anchored in safety.

### CPFM: An International Best Practice

**United Kingdom**

*Since the 1980s, pavement friction of the English Strategic Road Network has been managed through a requirement to provide specific levels of skid resistance and texture depth, using CPFM as the basis for monitoring. A 1991 paper by Rogers and Gargett referenced a National Skidding Resistance Survey report that estimated this approach would result in 6 percent fewer casualties per year on trunk roads, and a benefit-cost ratio of 5.5-to-1. In 2016, the Transport Research Laboratory published PPR 806, which further reviewed the relationship between crash risk and skid resistance. The study found that for curves and steep grades, roadways with higher skid resistance have a lower risk of collisions, even in wet conditions, and recommended that enhanced skid resistance treatments be prioritized for those sites.*

**New Zealand**

*Throughout the 1990s, the New Zealand Transport Agency (NZTA) sponsored road surface friction research and development and established their first skid resistance policy and specification in 1997, which required CPFM equipment be used for network skid resistance measurement. Consistent with UK experience, the 1998 Transfund New Zealand Research Report 141 documented a statistically significant relationship between crashes and skid resistance at junctions, curves and steep grades, and indicated that wet road crashes could be reduced 45-61% at these locations with targeted enhanced skid resistance. Finally, a 2011 paper by Whitehead, et al, reviewed 11 years of experience with the NZTA policy and found the benefit-cost ratio ranged between 13:1 and 35:1.*

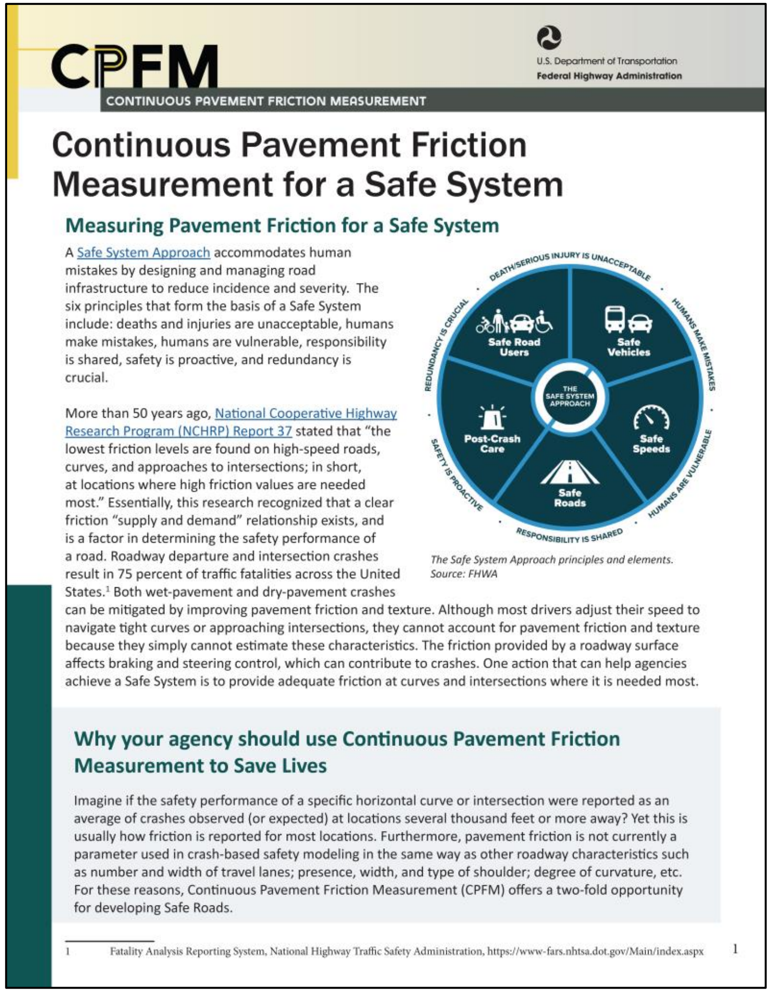
**Including pavement friction as a parameter in road safety performance modeling, establishing friction performance thresholds based on context, and proactively and systemically managing friction can help your agency achieve its road safety goals to save lives and prevent serious injuries.**

**For more information:**

| | | | |
|---|---|---|---|
| **FHWA Office of Safety** | | **FHWA Resource Center** | |
| **Jeff Shaw** | **Jeffrey.shaw@dot.gov** | **Andy Mergenmeier** | **Andy.mergenmeier@dot.gov** |

**FHWA-SA-21-014**

CPFM CONTINUOUS PAVEMENT FRICTION MEASUREMENT



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CONTINUOUS PAVEMENT FRICTION MEASUREMENT

## Continuous Pavement Friction Measurement for a Safe System

### Measuring Pavement Friction for a Safe System

A Safe System Approach accommodates human mistakes by designing and managing road infrastructure to reduce incidence and severity. The six principles that form the basis of a Safe System include: deaths and injuries are unacceptable, humans make mistakes, humans are vulnerable, responsibility is shared, safety is proactive, and redundancy is crucial.

More than 50 years ago, National Cooperative Highway Research Program (NCHRP) Report 37 stated that "the lowest friction levels are found on high-speed roads, curves, and approaches to intersections; in short, at locations where high friction values are needed most." Essentially, this research recognized that a clear friction "supply and demand" relationship exists, and is a factor in determining the safety performance of a road. Roadway departure and intersection crashes result in 75 percent of traffic fatalities across the United States.[1] Both wet-pavement and dry-pavement crashes can be mitigated by improving pavement friction and texture. Although most drivers adjust their speed to navigate tight curves or approaching intersections, they cannot account for pavement friction and texture because they simply cannot estimate these characteristics. The friction provided by a roadway surface affects braking and steering control, which can contribute to crashes. One action that can help agencies achieve a Safe System is to provide adequate friction at curves and intersections where it is needed most.

*The Safe System Approach principles and elements. Source: FHWA*

### Why your agency should use Continuous Pavement Friction Measurement to Save Lives

Imagine if the safety performance of a specific horizontal curve or intersection were reported as an average of crashes observed (or expected) at locations several thousand feet or more away? Yet this is usually how friction is reported for most locations. Furthermore, pavement friction is not currently a parameter used in crash-based safety modeling in the same way as other roadway characteristics such as number and width of travel lanes; presence, width, and type of shoulder; degree of curvature, etc. For these reasons, Continuous Pavement Friction Measurement (CPFM) offers a two-fold opportunity for developing Safe Roads.

1 Fatality Analysis Reporting System, National Highway Traffic Safety Administration, https://www-fars.nhtsa.dot.gov/Main/index.aspx

1

https://highways.dot.gov/safety/rwd/keep-vehicles-road/pavement-friction/cpfm

# Conclusions

- The collection of continuous friction and macrotexture data through the adoption of CPFM along with systemic pavement friction management (PFM) can have a significant impact on crash reductions.
- Measuring friction continuously (macro and micro), especially when complemented by road geometry data, provides a more effective method for identifying the most critical sections and allow focusing the safety improvement efforts on the higher risk locations, such as intersections and curves.

**Source:** FHWA/Andy Mergenmeier

**Source:** PennDOT

# Friction for Safe System Redundancy

The "Swiss Cheese Model" of redundancy creates layers of protection

Death and serious injuries only happen when all layers fail


Source: FHWA

# Thank You!

THE SAFE SYSTEM APPROACH

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

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