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

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Office of Safety

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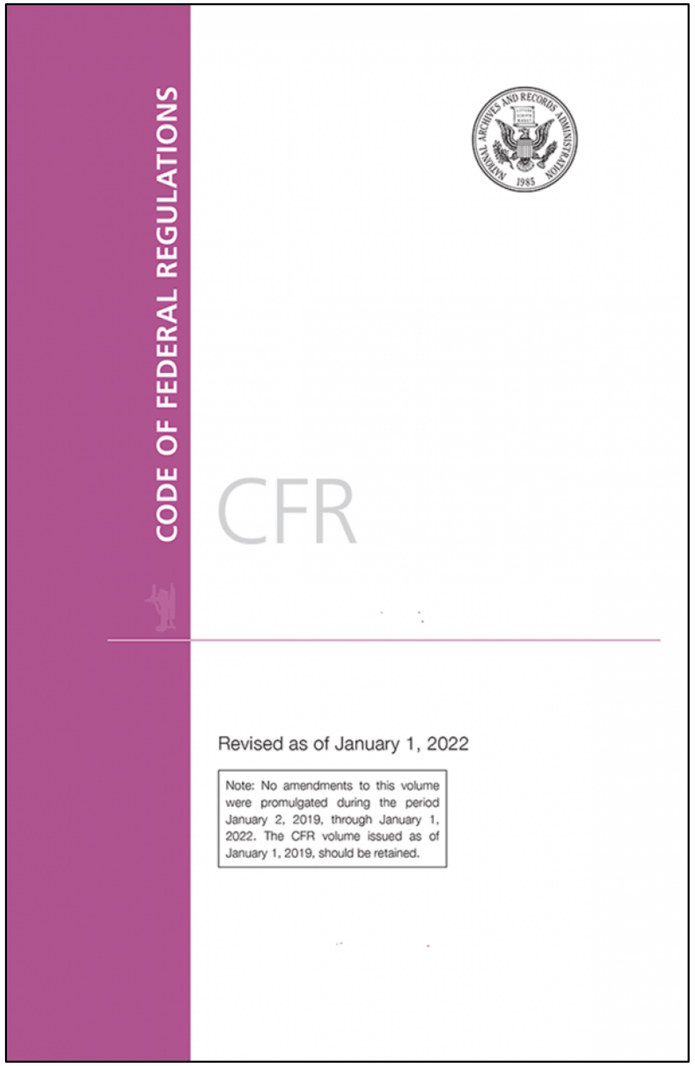
23 CFR Part 626



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

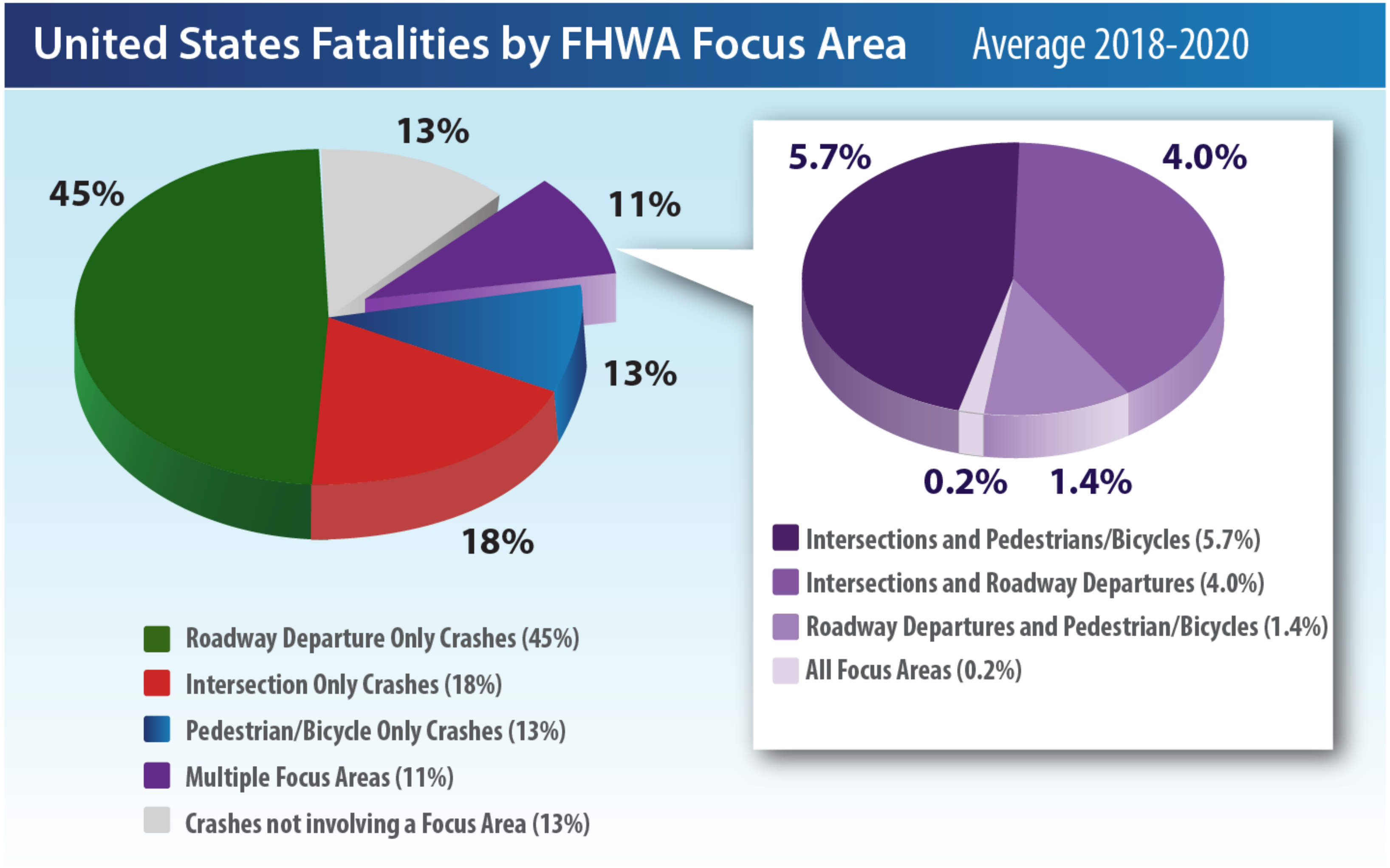
The crisis on our roadways **continues to worsen** based on estimated roadways fatalities in 2021:

Estimates of Motor Vehicle Traffic Fatalities, 2020 vs. 2021		
2020 Estimates	2021 Estimates	Percent Increase from 2020 to 2021
38,824	42,915	**10.5%**

The largest number of projected fatalities since 2005.

Source: *Early Estimate of Motor Vehicle Traffic Fatalities, National Highway Traffic Safety Administration*

U.S. Fatalities by Focus Area



SOURCE: FARS
FHWA definitions available at safety.fhwa.dot.gov/fas
NOTE: Numbers in the pie charts may not add exactly due to rounding.

Tennessee Safety Priorities

Figure 20 - Fatalities and Serious Injuries by Infrastructure Type (2013-2017)

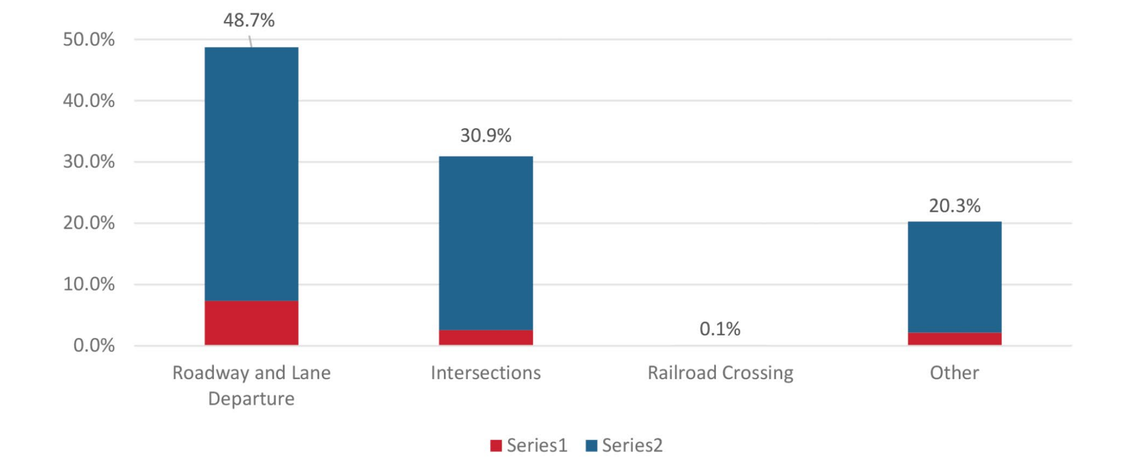
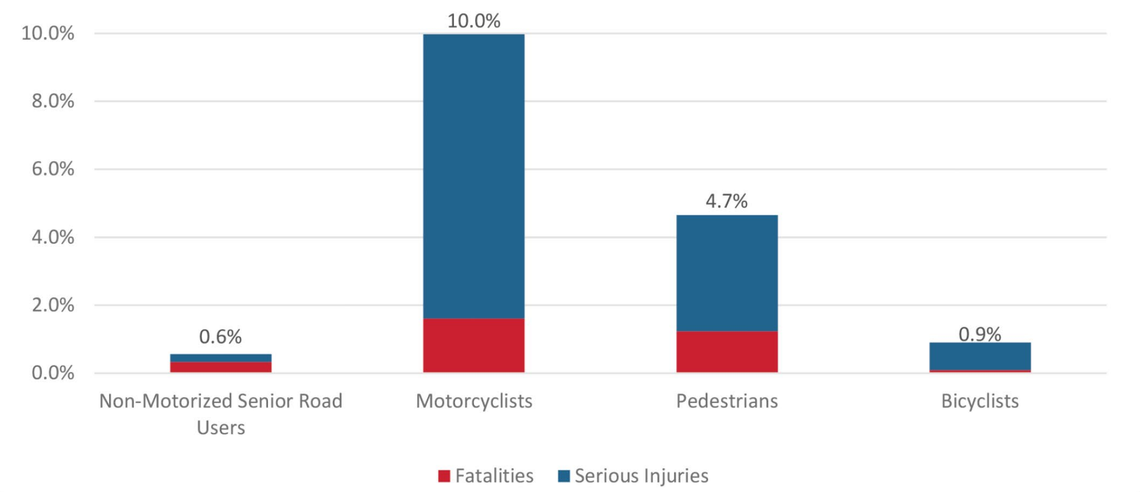


Figure 24 - Vulnerable Road User Fatalities and Serious Injuries by Type of User (2013-2017)



Tennessee Friction Experience

- Systemic applications of HFST is already established in TN
- This experience can be leveraged toward a more comprehensive pavement friction management program

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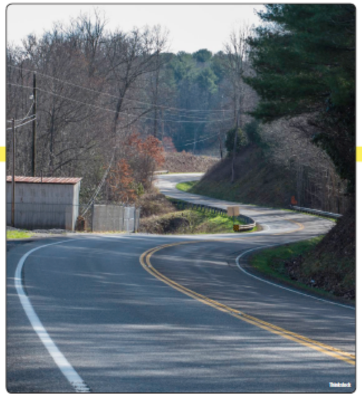
NOTEWORTHY PRACTICE

TENNESSEE — HIGH FRICTION SURFACE TREATMENT (HFST)

Systemic Applications of High Friction Surface Treatment in Tennessee



What was the safety issue, problem, or gap?

In 2010, the Tennessee Department of Transportation (TDOT) created a Safety Office to analyze crash types, causes, and severity. In 2011, Tennessee adopted their Roadway Departure Implementation Plan, which included high friction surface treatments (HFST). Up to that time, TDOT had implemented HFST at ten locations statewide, primarily for lengthening bridge lifecycles, and were now interested in widespread deployment of the treatment as a safety improvement through the State's HFST Initiative.

What were the key challenges that needed to be addressed before the new practice could be implemented?

Relatively new to HFST implementation, TDOT wanted to utilize a data-driven procedure to select sites where HFST could effectively improve safety as they launched the Initiative. TDOT regarded crash history and site-specific conditions related to pavement conditions, existing delineations, proximity to other curves, and other factors as important considerations for selecting appropriate sites. However, analysis of these criteria was no small feat and required field visits to each candidate location by Safety and Pavement/Materials Office staff.

TDOT requires a defined need before obligating safety funds for any improvement. It was important to not only document how safety at a particular site may improve after HFST installation, but to limit HFST use to locations with sufficient pavement integrity, allowing HFST to last a full life span of up to 10 years.

Describe the new practice:

TDOT employed three approaches to help determine potential locations to include in their HFST Initiative, such as:

REACTIVE	PROACTIVE	EVENT-BASED
TDOT has an active Road Safety Audit (RSA) program and conducts an RSA at some locations with a significant crash history.	The DOT has an exhaustive horizontal curve inventory and overlays crash data onto known curve locations to identify opportunities to further investigate. Curves slated for HFST installation through this approach are included in TDOT's HFST Initiative and the project is programmed accordingly.	TDOT considers other spot locations as issues or opportunities arise, such as locations experiencing wet-weather related crashes or a curve with close proximity to an upcoming HFST installation.

NOTEWORTHY PRACTICE

TENNESSEE — HIGH FRICTION SURFACE TREATMENT (HFST)

TDOT mostly used the proactive approach to develop the candidate location list and relied on the following systemic process to do so:

1. **Overlay crash data onto horizontal alignment.** TDOT overlaid three years' of crash data onto their horizontal alignment inventory.
2. **Flag candidate locations and review data.** Staff isolated all curves with four or more crashes in three years for further review, noting those that were indicated as weather- or speed-related in the crash report.
3. **Perform field investigation.** Small teams of Safety Office and Pavement/Materials Office staff visited each candidate location to review and document curve geometry, sight distance, cross-slopes, existing safety improvements (e.g., signs, pavement marking), and evidence of past crashes (e.g., skid marks, damaged infrastructure). The team marked and documented potential limits for each HFST location and ensured signing and pavement markings were appropriate and in good condition.
4. **Narrow the list.** After field reviews, some locations were eliminated from the HFST Initiative for various reasons, including poor pavement integrity, crashes attributed to intersections within the curve, and others. Curves remaining on the list were grouped by proximity and programmed for installation.

Key accomplishments, including roadway safety improvements:

Since the launch of the HFST Initiative in 2011, TDOT has completed approximately 50 HFST projects ranging from 2-lane rural to 5-lane urban locations, and approximately 60 locations were selected for HFST applications in the past year. TDOT plans to complete performance evaluations for the HFST installations, after collecting three to five years of crash data.

HFST Open House by TDOT

Additionally, TDOT held an "open house" event in 2015, as seen in photo, where they provided nearly 50 participants representing local agencies, engineering consultants, TDOT, FHWA, and universities with an opportunity to learn more about HFST application, benefits, and costs. The event included a live, on-site demonstration of HFST installation by the TDOT Materials and Test Division; presentations on HFST history, development, effectiveness, and installation; and an opportunity for questions and answers with TDOT and FHWA presenters.

What technical and/or institutional changes resulted from the new practice?

TDOT's systemic HFST implementation has impacted local agencies; several have expressed a desire to try HFST and contacted TDOT for guidance and information. Along with their impressive local route inventory, local agencies in Tennessee have a solid funding mechanism that can sustain HFST installations on the local network.

What benefits were realized as a result of the practice?

Applying a systemic approach and rigorously vetting proposed locations ultimately helped leadership support the HFST initiative and moved it forward. The process also garnered support and proved to be beneficial at the local agency level.

Safe Roads for a Safer Future
http://safety.fhwa.dot.gov
FHWA-SA-16-058

FOR MORE INFORMATION

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

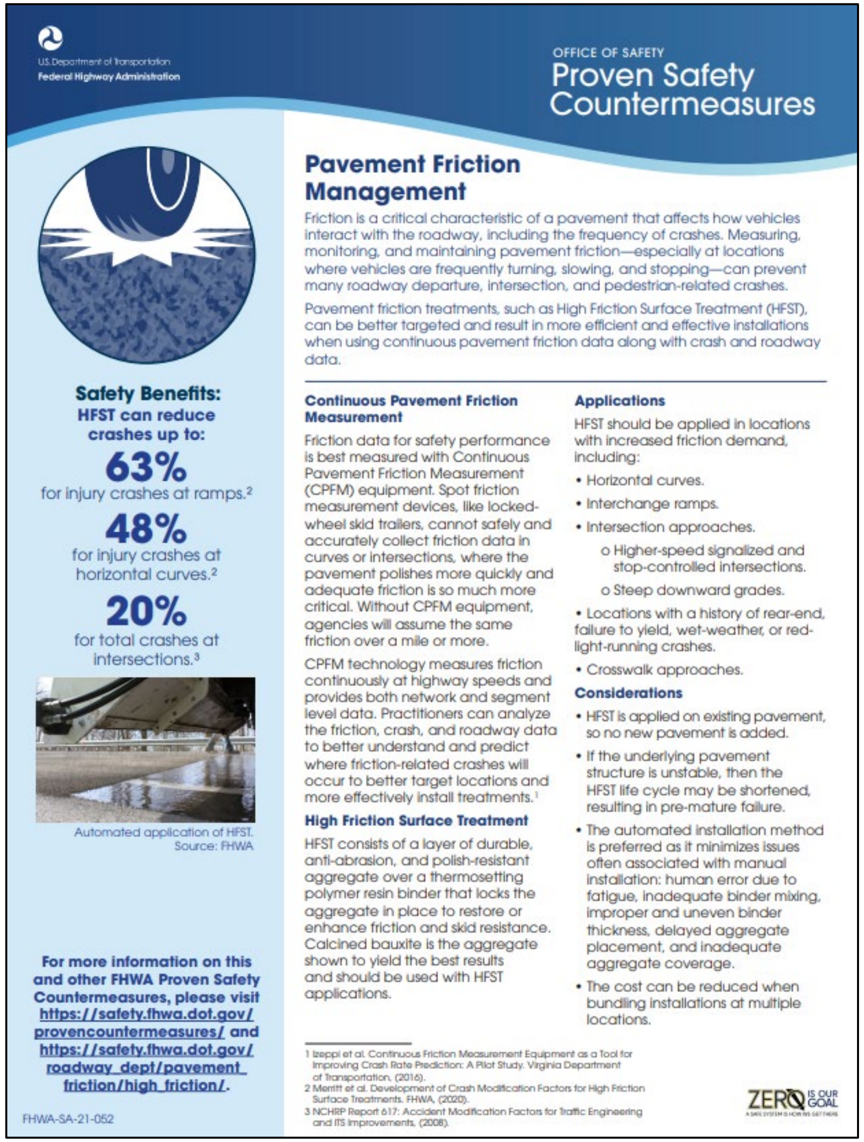
A New Direction

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.
  - Higher-speed signalized and stop-controlled intersections.
  - 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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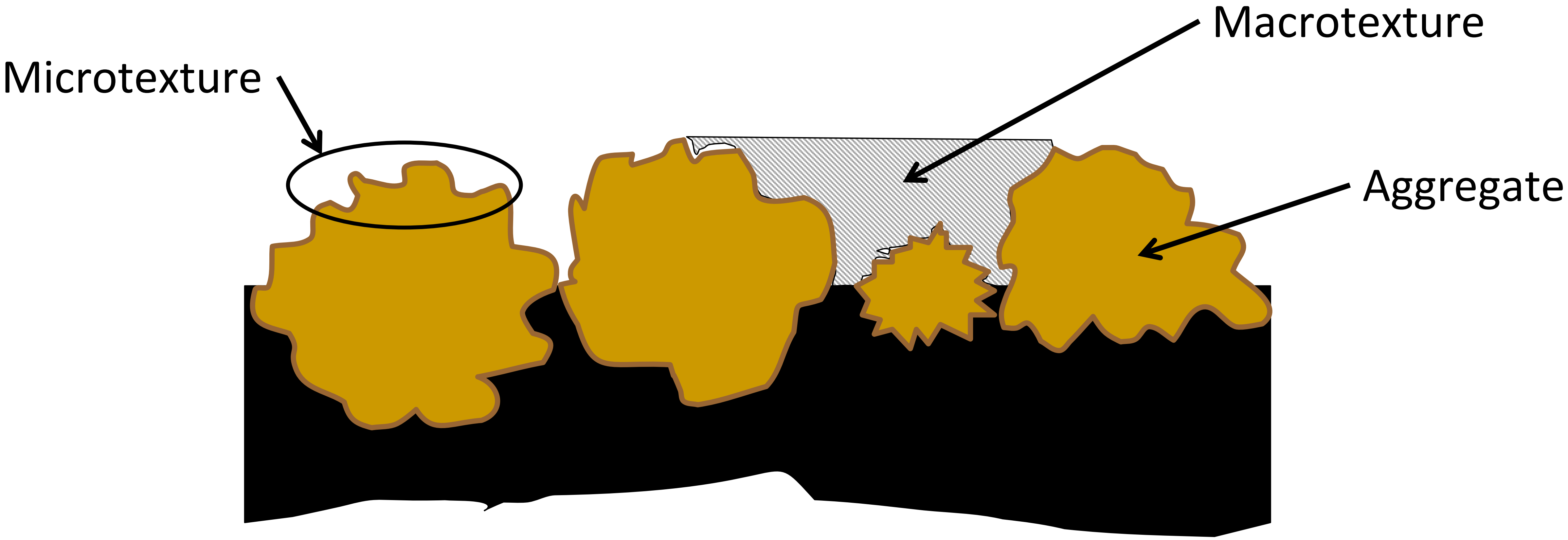
- Originally High Friction Surface Treatment (HFST)
- 2021 PSC Update expanded this to be the foundation of Pavement Friction Management
  - Still includes HFST
  - Added Continuous Pavement Friction Measurement (CPFM)
  - Recognizes benefits at additional locations
  - Proactive safety approach that dovetails with pavement preservation and asset management

What is Texture?

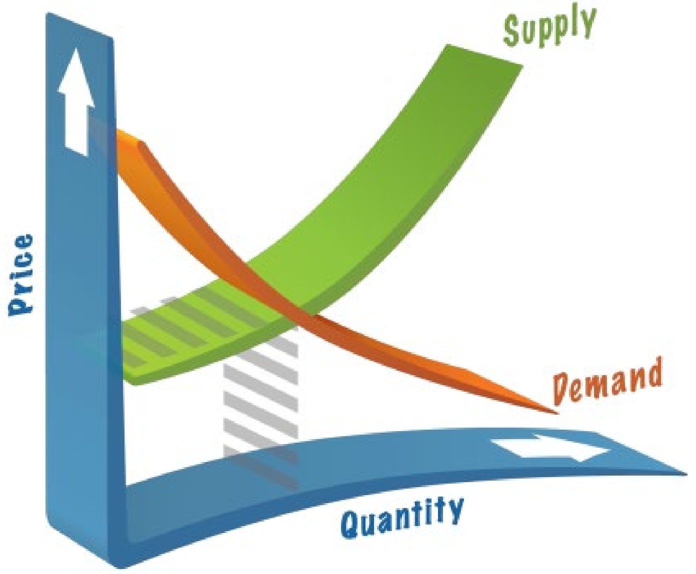


Pavement Cross Section

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

Friction Considerations

- Friction is a function of pavement surface macrotexture <u>and</u> microtexture
- Friction demand is that needed to safely perform braking, steering, and acceleration maneuvers
- Pavement Friction Design Objective:
  - Design for end-of-life friction meeting road friction demand
  - Different roads have different friction demand



Surrogate Approach

Source: Federal Highway Administration.

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

Typical U.S. Field 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)
- Even when done at network level this is sample-based testing

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

Continuous Friction Measurement

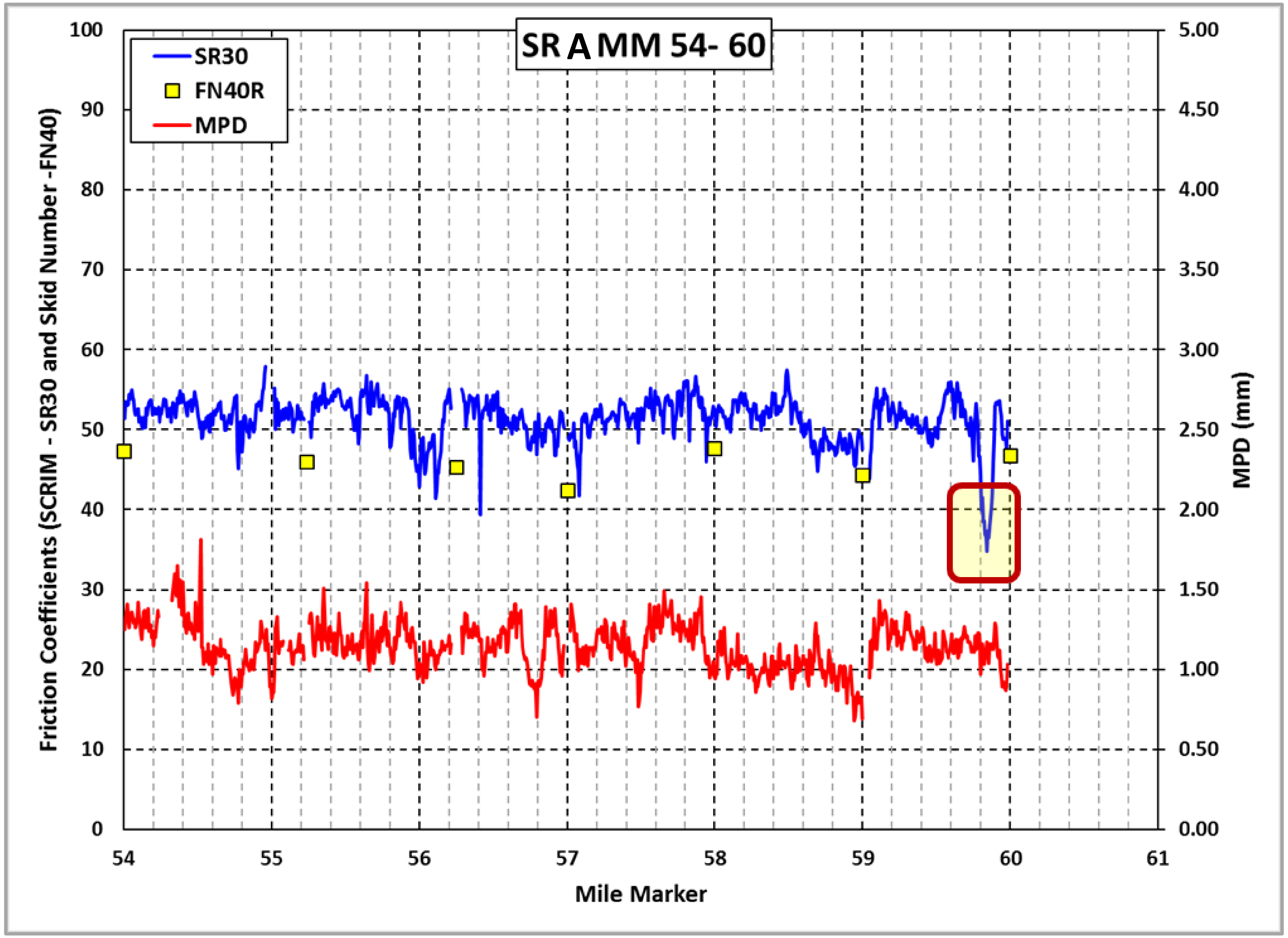
Source: Center for Sustainable Transportation Infrastructure (CSTI)/ Virginia Tech Transportation Institute (VTTI).

Source: FHWA.

Source: FHWA.

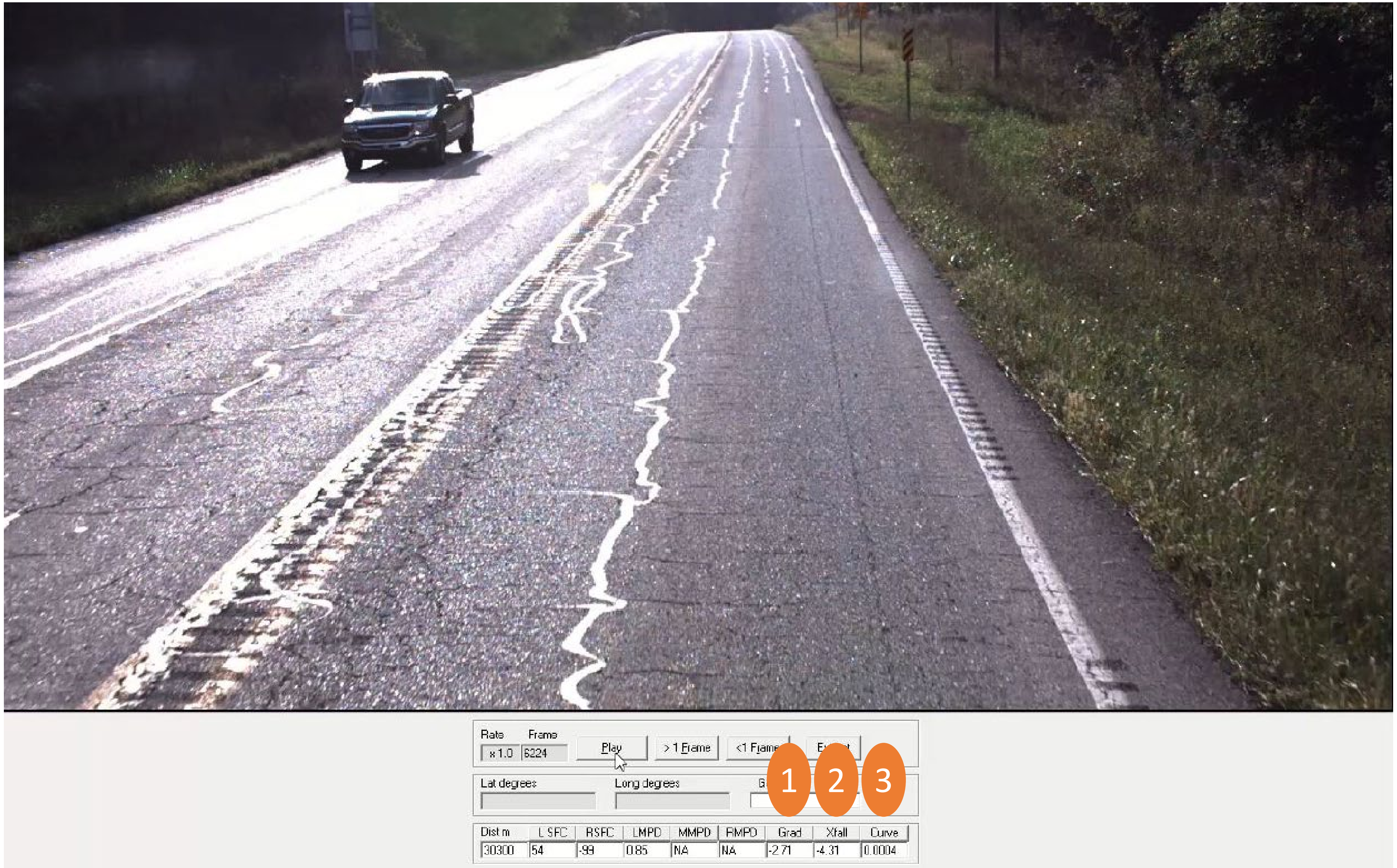
Sideway-force Coefficient Routine Investigation Machine

Sample Data vs. Continuous Data



Source: Federal Highway Administration.

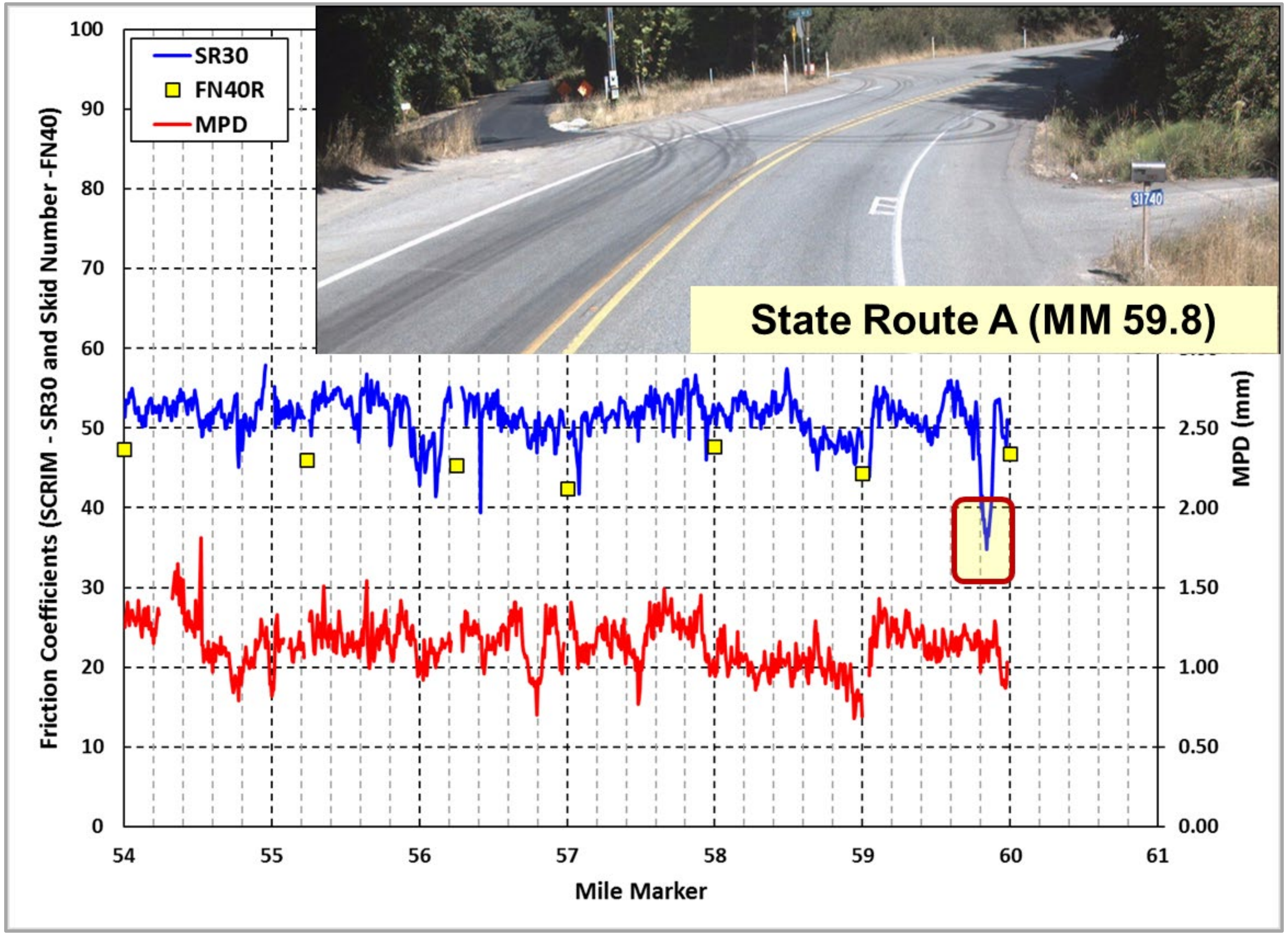
Additional Data Collection Ability



SCRIM also collects:

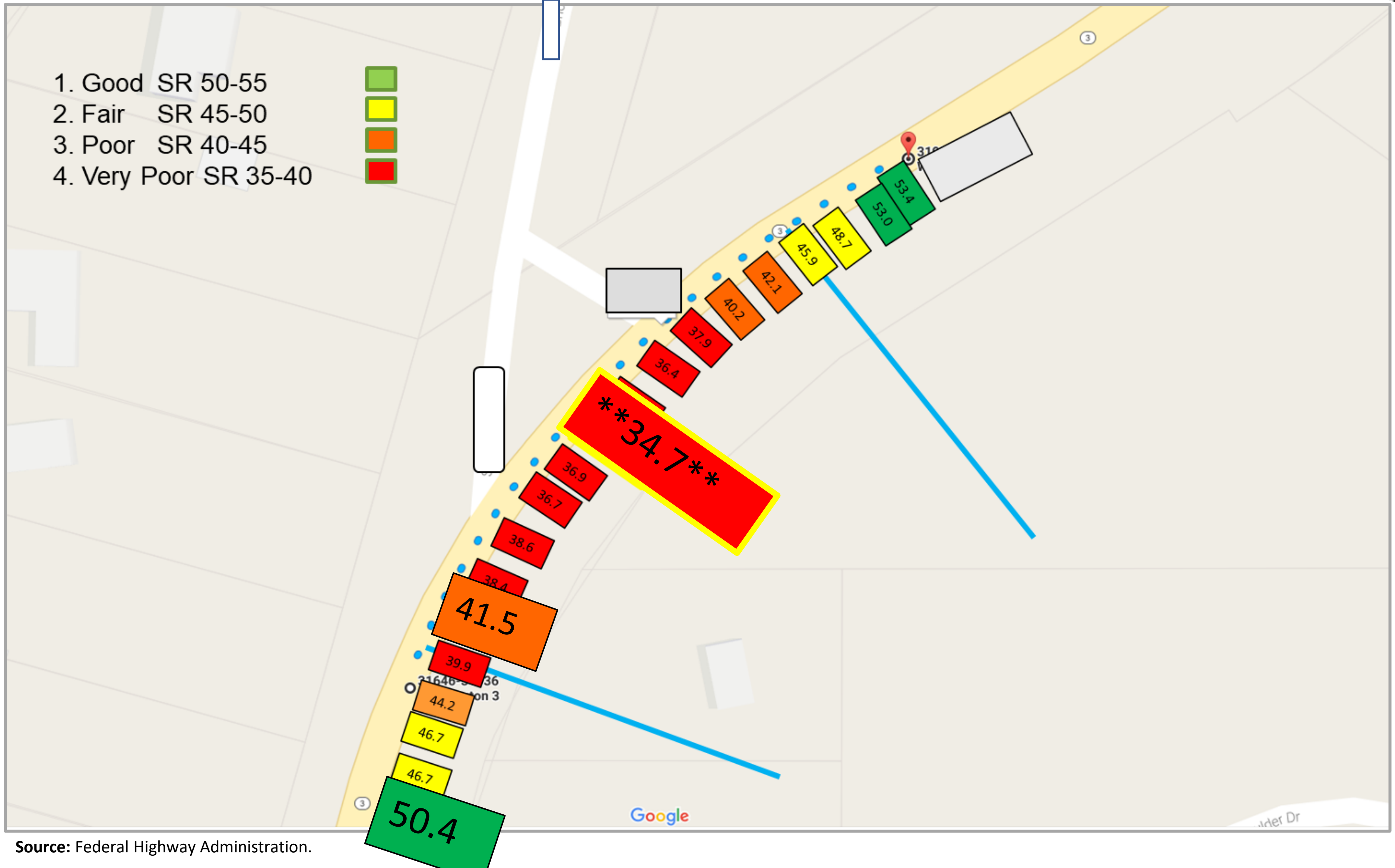
1. Grade
2. Cross-slope
3. Curvature

Complete Picture on Friction



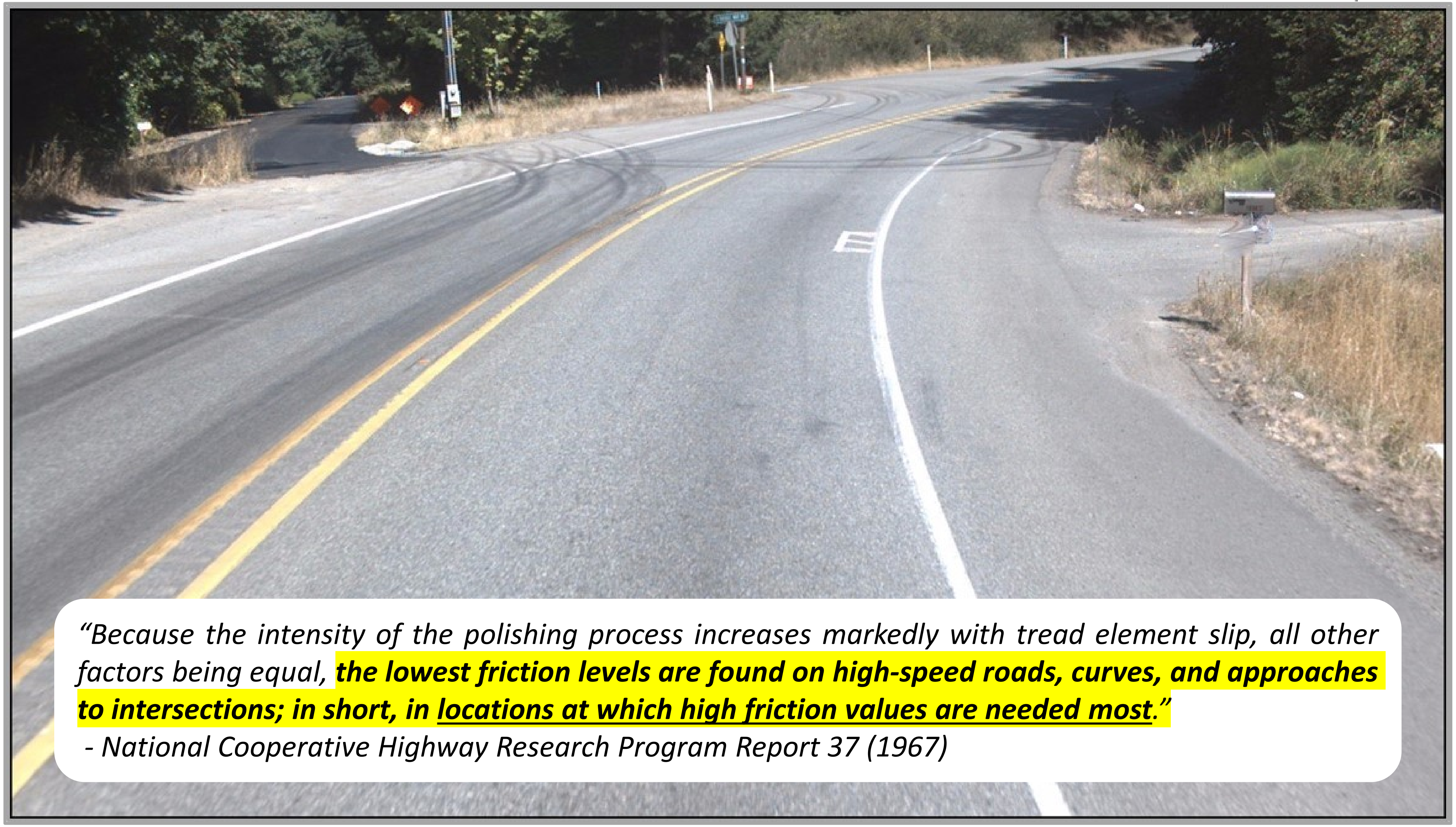
Source: Federal Highway Administration.

CPFM Resolution



Source: Federal Highway Administration.

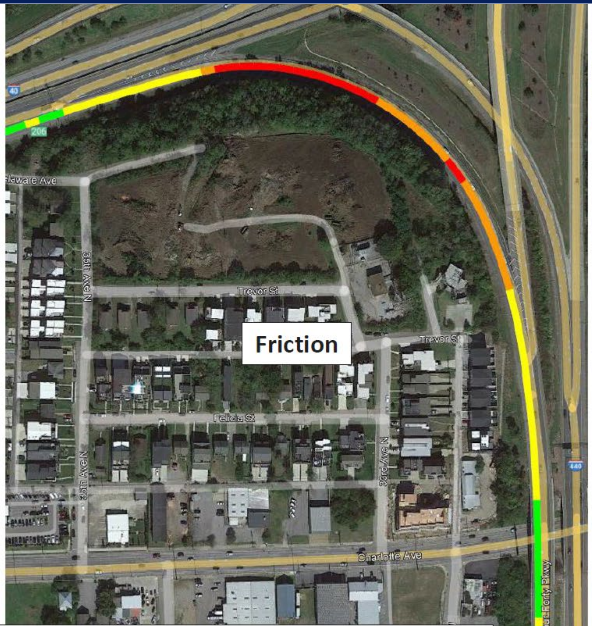
NCHRP Report 37

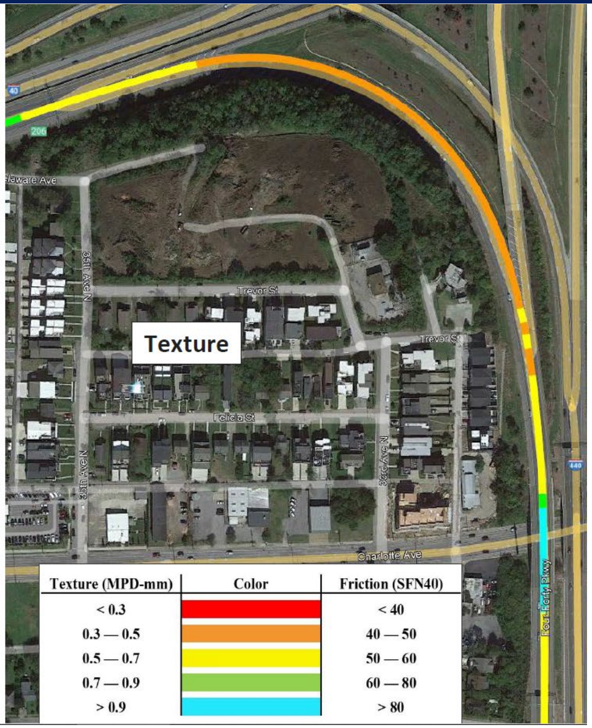


"Because the intensity of the polishing process increases markedly with tread element slip, all other factors being equal, ***the lowest friction levels are found on high-speed roads, curves, and approaches to intersections; in short, in locations at which high friction values are needed most****."*

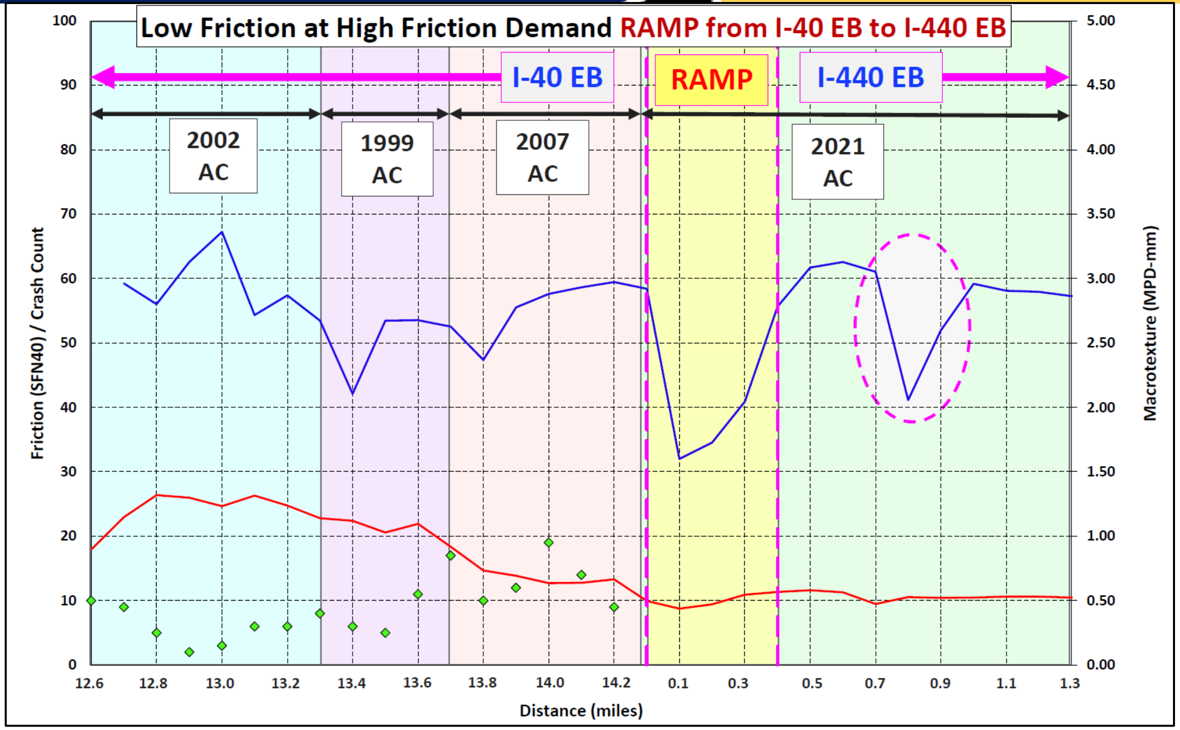
- National Cooperative Highway Research Program Report 37 (1967)

TN CPFM Pilot Demo Examples

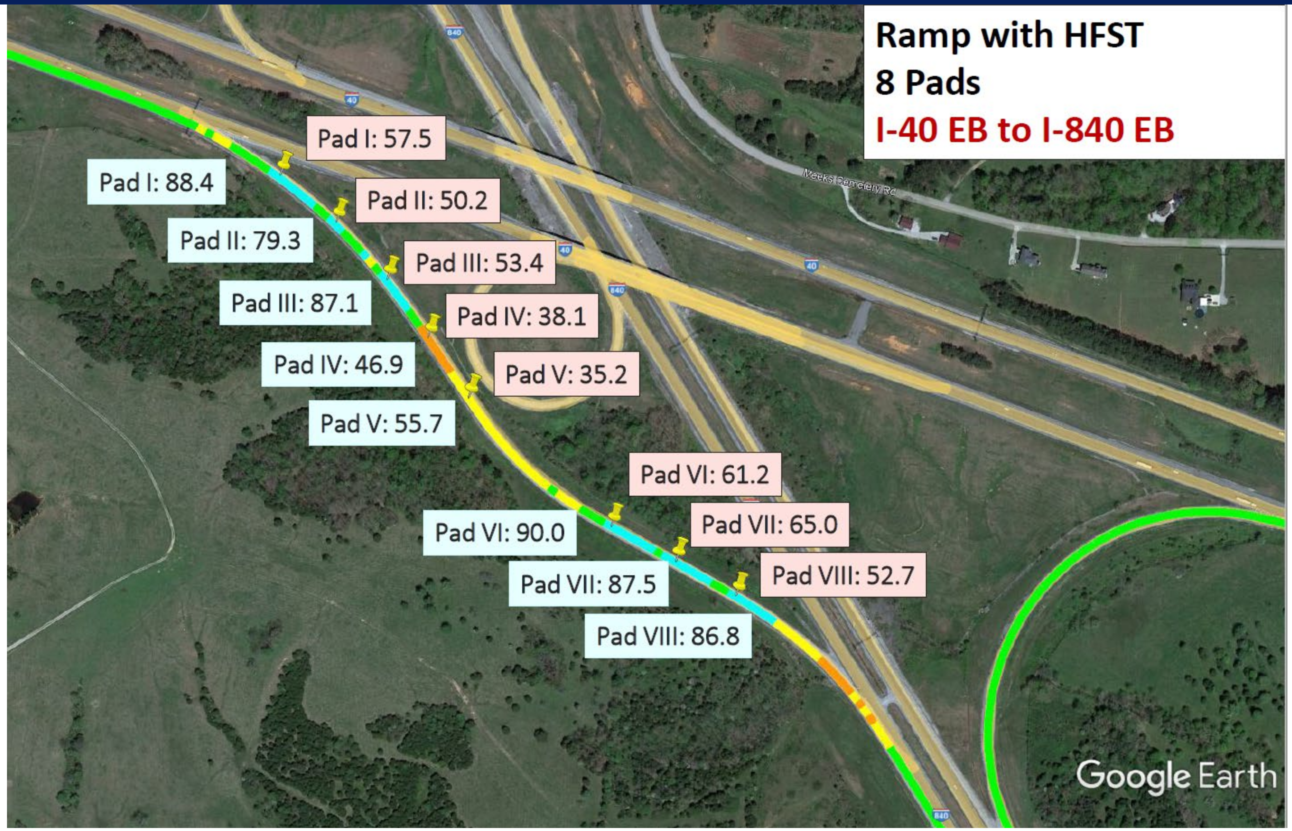


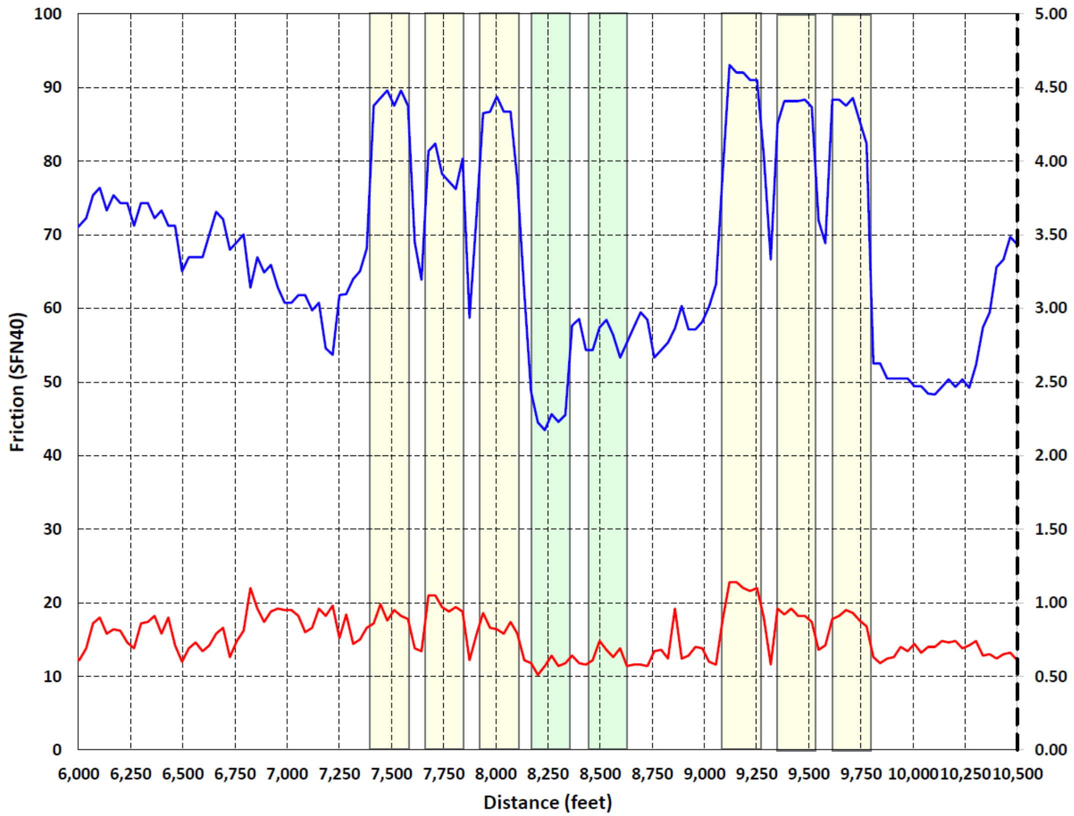


Low Friction at High Friction Demand
RAMP from I-40 EB to I-440 EB



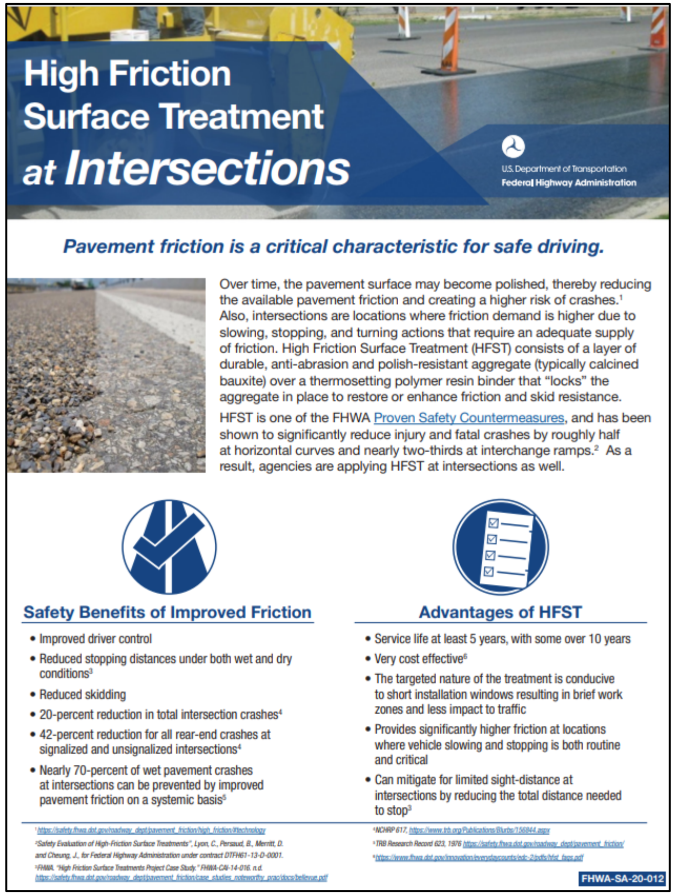
TN CPFM Pilot Demo Examples





Matching Supply to Demand

- Recent HFST/friction experience has been mostly limited to horizontal curves and ramps
- Past evaluations of enhanced skid resistance (not HFST) at intersections has shown significant benefits
  - 20% reduction in total crashes
  - 42% reduction for rear-end crashes
  - 70% reduction of wet pavement crashes



High Friction Surface Treatment at Intersections

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Federal Highway Administration

Pavement friction is a critical characteristic for safe driving.

Over time, the pavement surface may become polished, thereby reducing the available pavement friction and creating a higher risk of crashes.[1] Also, intersections are locations where friction demand is higher due to slowing, stopping, and turning actions that require an adequate supply of friction. High Friction Surface Treatment (HFST) consists of a layer of durable, anti-abrasion and polish-resistant aggregate (typically calcined bauxite) over a thermosetting polymer resin binder that "locks" the aggregate in place to restore or enhance friction and skid resistance.

HFST is one of the FHWA Proven Safety Countermeasures, and has been shown to significantly reduce injury and fatal crashes by roughly half at horizontal curves and nearly two-thirds at interchange ramps.[2] As a result, agencies are applying HFST at intersections as well.

Safety Benefits of Improved Friction

- Improved driver control
- Reduced stopping distances under both wet and dry conditions[3]
- Reduced skidding
- 20-percent reduction in total intersection crashes[4]
- 42-percent reduction for all rear-end crashes at signalized and unsignalized intersections[4]
- Nearly 70-percent of wet pavement crashes at intersections can be prevented by improved pavement friction on a systemic basis[5]

Advantages of HFST

- Service life at least 5 years, with some over 10 years
- Very cost effective[6]
- The targeted nature of the treatment is conducive to short installation windows resulting in brief work zones and less impact to traffic
- Provides significantly higher friction at locations where vehicle slowing and stopping is both routine and critical
- Can mitigate for limited sight-distance at intersections by reducing the total distance needed to stop[3]

[1] https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/high_friction/#technology
[2] "Safety Evaluation of High-Friction Surface Treatments", Lyon, C., Persaud, B., Merritt, D. and Cheung, J., for Federal Highway Administration under contract DTFH61-13-D-0001.
[3] FHWA. "High Friction Surface Treatments Project Case Study." FHWA-CAI-14-016. n.d. https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/case_studies_noteworthy_prac/docs/bellevue.pdf
[4] NCHRP 617, https://www.trb.org/Publications/Blurbs/156844.aspx
[5] TRB Research Record 623, 1976 https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/
[6] https://www.fhwa.dot.gov/innovation/everydaycounts/edc-2/pdfs/hfst_faqs.pdf

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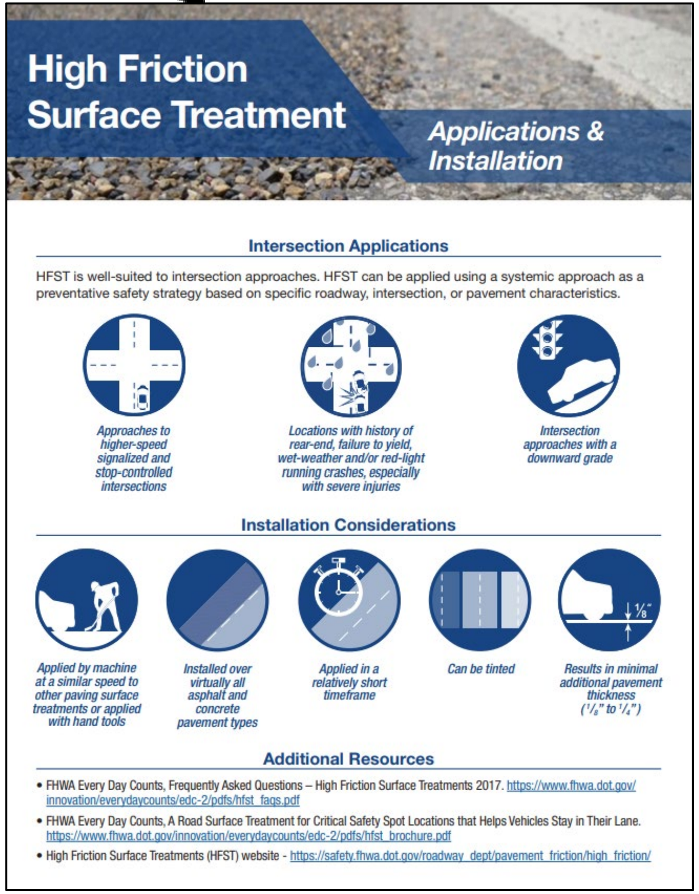


High Friction Surface Treatment

Applications & Installation

Intersection Applications

HFST is well-suited to intersection approaches. HFST can be applied using a systemic approach as a preventative safety strategy based on specific roadway, intersection, or pavement characteristics.

- *Approaches to higher-speed signalized and stop-controlled intersections*
- *Locations with history of rear-end, failure to yield, wet-weather and/or red-light running crashes, especially with severe injuries*
- *Intersection approaches with a downward grade*

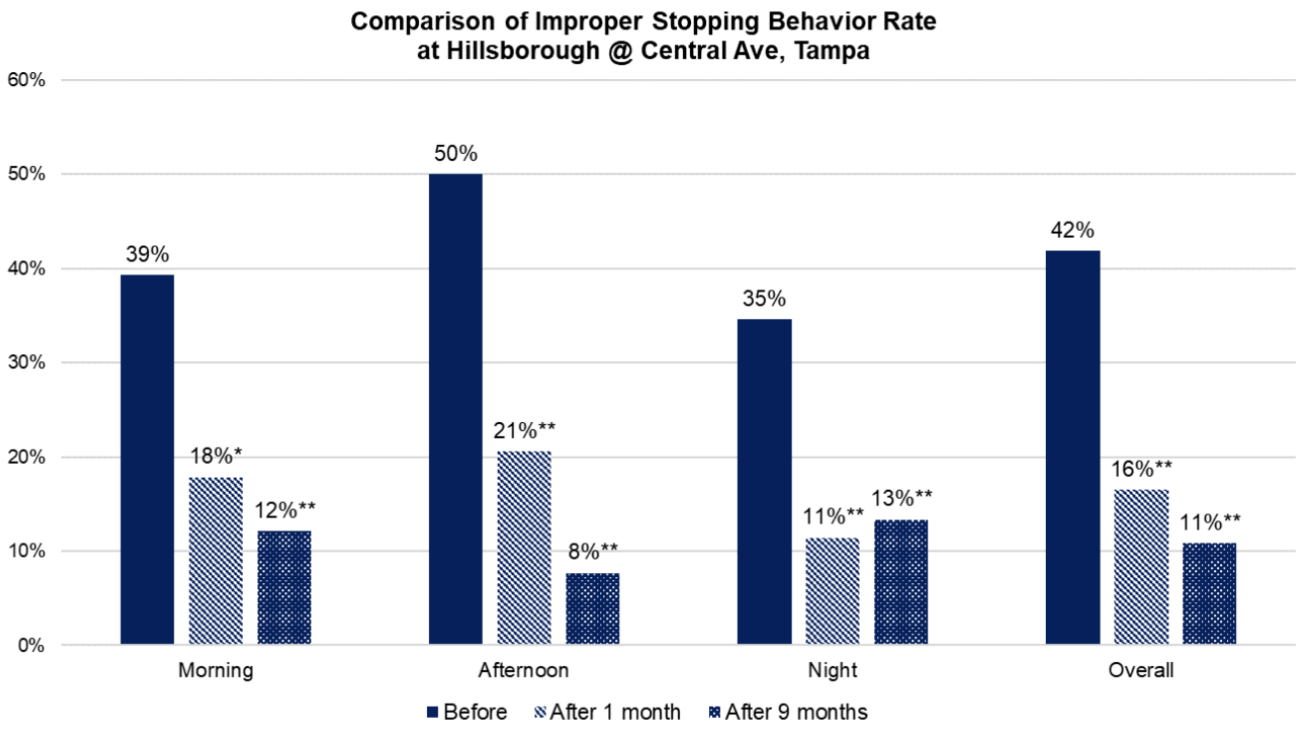
Installation Considerations

- *Applied by machine at a similar speed to other paving surface treatments or applied with hand tools*
- *Installed over virtually all asphalt and concrete pavement types*
- *Applied in a relatively short timeframe*
- *Can be tinted*
- *Results in minimal additional pavement thickness (1/8" to 1/4")*

Additional Resources

- FHWA Every Day Counts, Frequently Asked Questions – High Friction Surface Treatments 2017. https://www.fhwa.dot.gov/innovation/everydaycounts/edc-2/pdfs/hfst_faqs.pdf
- FHWA Every Day Counts, A Road Surface Treatment for Critical Safety Spot Locations that Helps Vehicles Stay in Their Lane. https://www.fhwa.dot.gov/innovation/everydaycounts/edc-2/pdfs/hfst_brochure.pdf
- High Friction Surface Treatments (HFST) website - https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/high_friction/

Florida Intersection Case Study



** significant at a 95% confidence level
* significant at a 90% confidence level

Results from analysis of stopping behavior at Central Ave. intersection before and after HFST application. (Source: CUTR)

- District 7 (Tampa)
- Used CPFM and crash data to conduct intersection Road Safety Assessment
- Pre-HFST: FN40R = 37
- Post-HFST: FN40R = 79
- Before/After crash data analysis pending

UK Friction Management Levels

Site category and definition		Investigatory level (50 or 80 km/h)							
		0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
A	Motorway	Lower Risk	Normal Risk						
B	Dual carriageway non-event	Lower Risk	Normal Risk	Normal Risk					
C	Single carriageway non-event		Lower Risk	Normal Risk	Normal Risk				
Q	Approaches to and across minor and major junctions, approaches to roundabouts				Normal Risk	Normal Risk	Normal Risk		
K	Approaches to pedestrian crossings and other high risk situations					Normal Risk	Normal Risk		
R	Roundabout				Normal Risk	Normal Risk			
G1	Gradient 5-10% longer than 50m				Normal Risk	Normal Risk			
G2	Gradient >10% longer than 50m				Lower Risk	Normal Risk	Normal Risk		
S1	Bend radius < 500m - dual carriageway				Normal Risk	Normal Risk			
S2	Bend radius < 500m - single carriageway				Lower Risk	Normal Risk	Normal Risk		

Source: United Kingdom CS 228 Skidding Resistance Revision 0, August 2019.

LEGEND: Normal Risk (red) Lower Risk (pink)

Superior Approach

Source: Federal Highway Administration.

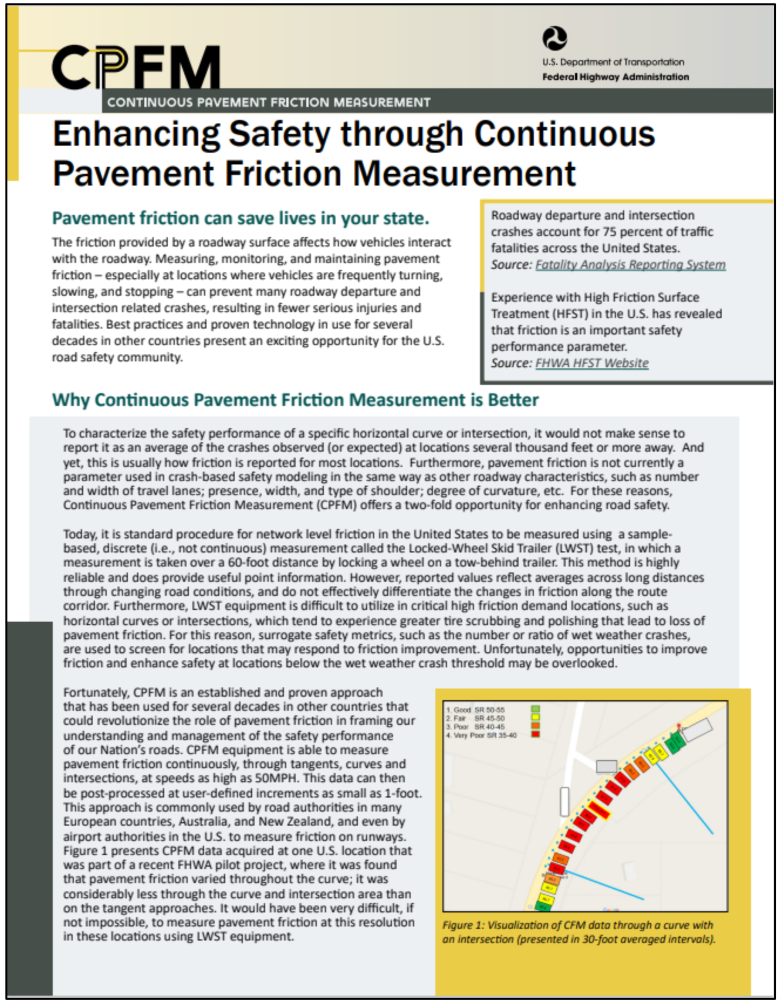
- Relies on crashes (reactive)

  25 crashes over past 3 years
- High wet-to-dry crash ratio
- Friction loss observed via CPFM
- Intervention programmed proactively

Conclusion

- 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.

For More Information



CPFM
CONTINUOUS PAVEMENT FRICTION MEASUREMENT

U.S. Department of Transportation
Federal Highway Administration

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.

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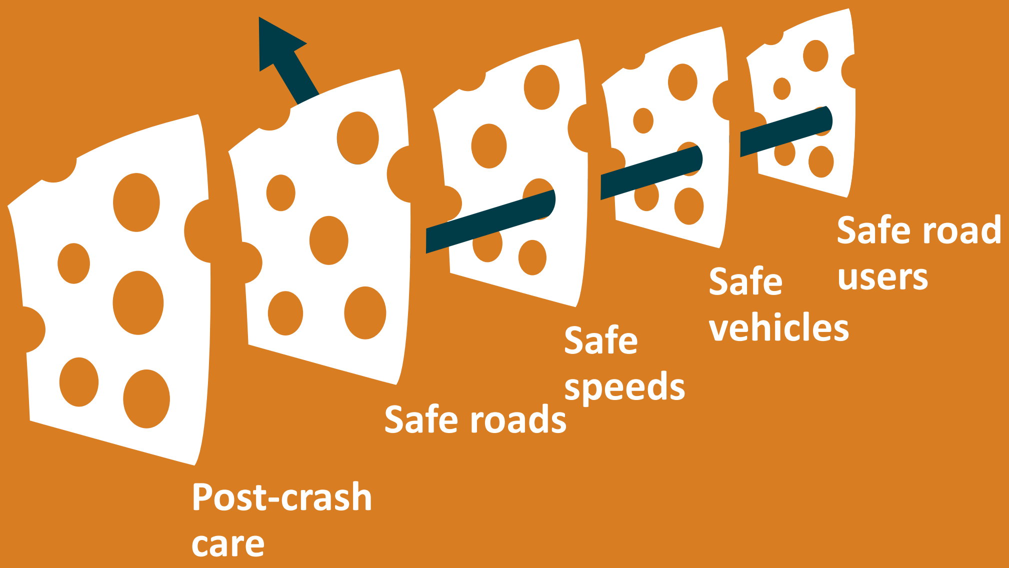
CPFM CONTINUOUS PAVEMENT FRICTION MEASUREMENT

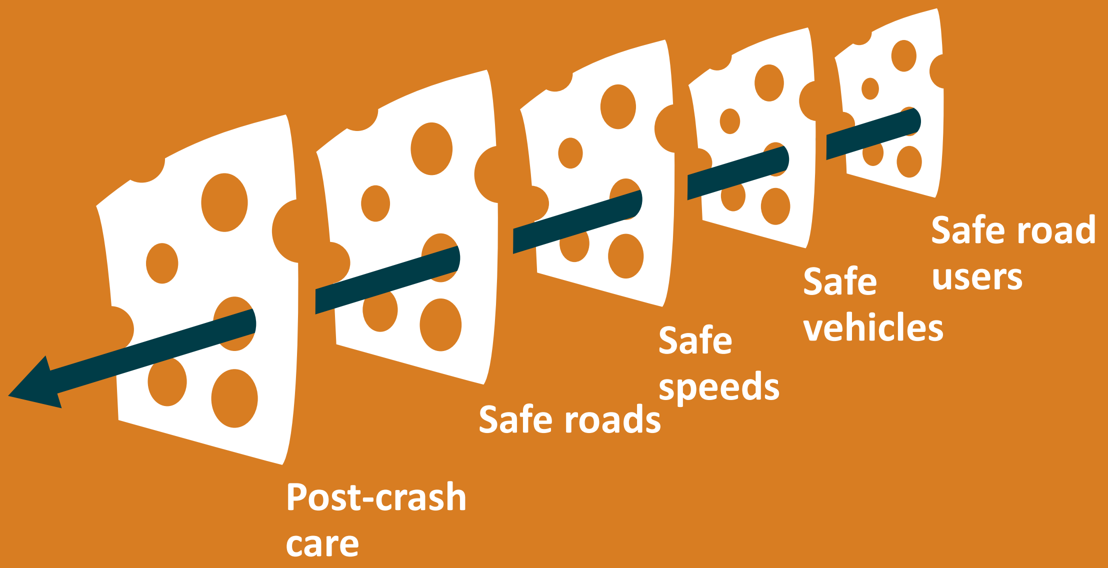
https://highways.dot.gov/safety/rwd/keep-vehicles-road/pavement-friction/cpfm

Safe Systems have 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.

Jeffrey Shaw – FHWA Office of Safety

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ZERO IS OUR GOAL

A SAFE SYSTEM IS HOW WE GET THERE