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SCRIM Friction Testing in the USA

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Virginia Tech Transportation Institute

Nashville, October 13th 2,016

ppc16

Outline

- Introduction: What is the SCRIM?
- Background and Friction 101
- Pavement Friction Management and Crash Data Analysis
- Case Studies (examples)
- Final Considerations

SCRIM

- Friction
- Macrotexture
- IMU + GPS
  - Grade
  - Cross-slope
  - Curvature
- Video (front)
- 2,400 gallons
- 150 miles of Continuous Data per tank

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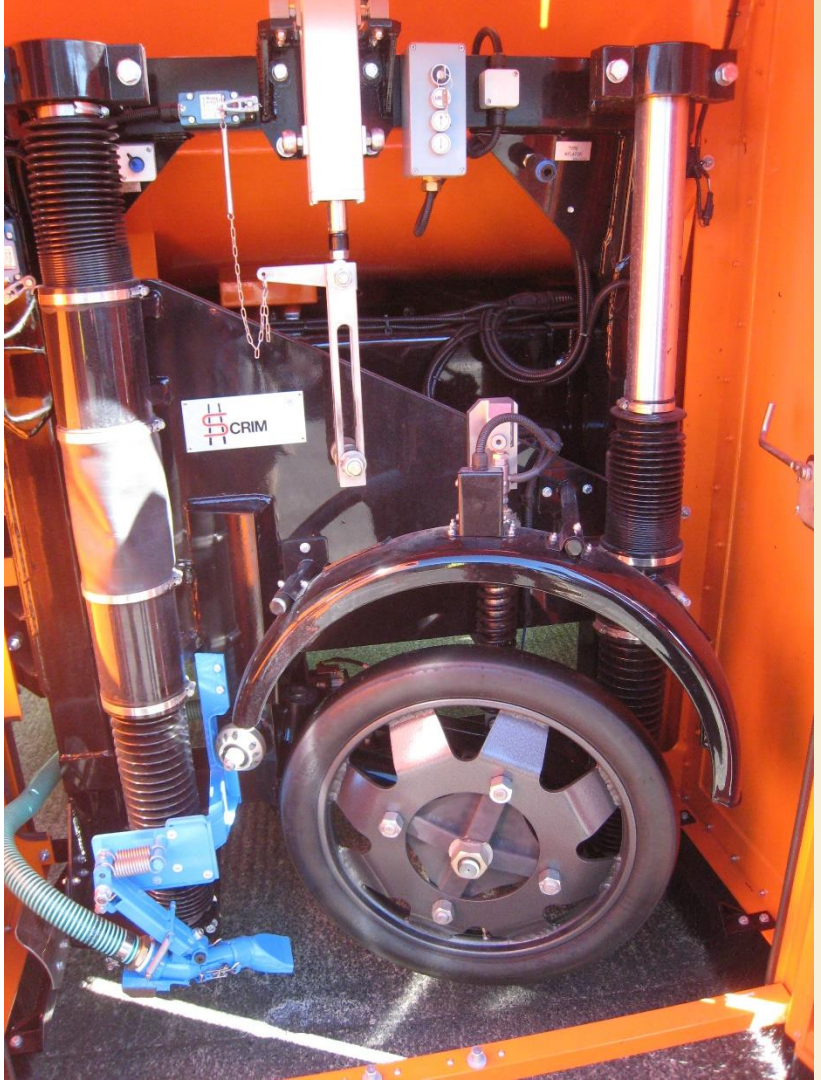
Sideway-Force Coefficient Routine Investigation Machine

- Electrical Systems: 24 vs 12 V
- EPA/EU diesel rules are not the same???

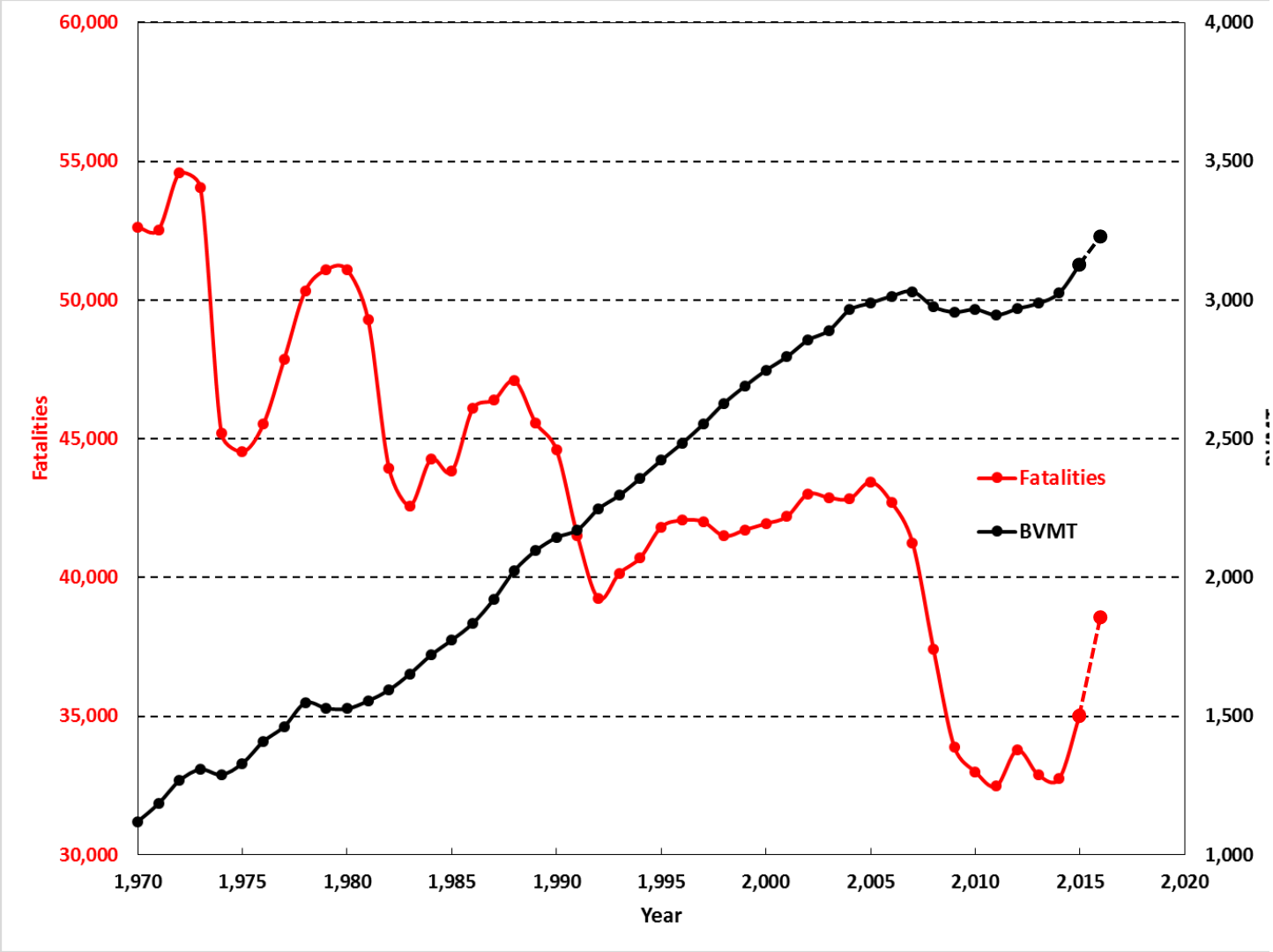
SCRIM

- **Friction**
  - Dynamic vertical load system
  - Dynamic water flow control
  - 20° skew angle for 34% slip speed
  - Operating speed of 15 – 55 mph
- **Macrotexture**
  - 64 kHz laser system



Background

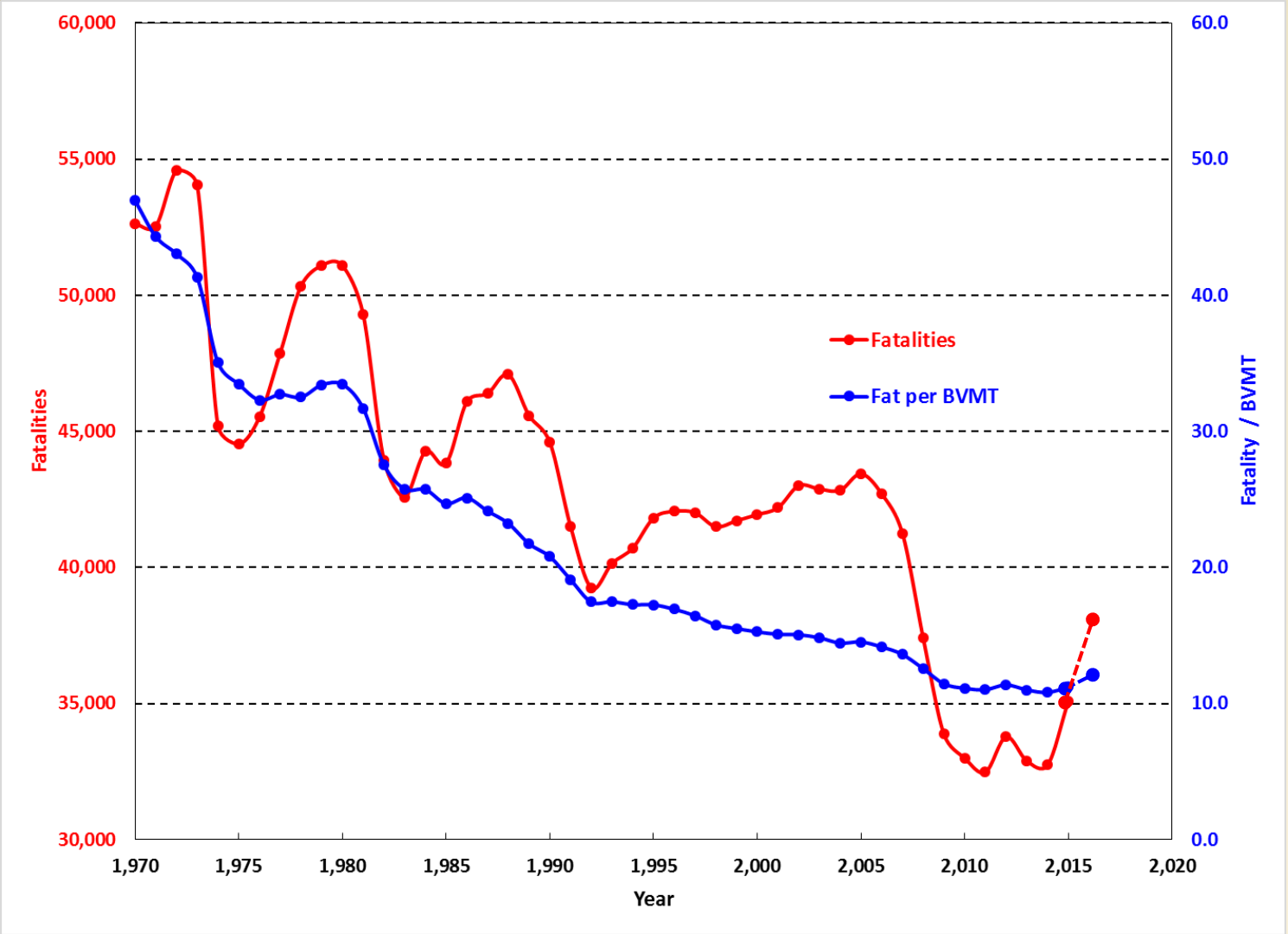
- **Federal Rulemaking**
- **Report:**
  - **Fatalities and Serious Injuries**
  - **Rate of Fatalities and Serious Injuries**



10/6/2016

NHSTA early projection

Deaths jump up 10.6% in first half of 2016


60,000
55,000
50,000
45,000
40,000
35,000
30,000
Fatalities
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fatality / BVMT
Fatalities
Fat per BVMT
1,970
1,975
1,980
1,985
1,990
1,995
2,000
2,005
2,010
2,015
2,020
Year

Background

1. SAFE
2. DURABLE
3. ECONOMIC

Fatality	1
Injury	55
PDO	120
Total	175

Virginia 2014

Est: 656 Fatal, 36,080 Injury, 78,720 PDO, 114,800 Total

Real: 656 Fatal, 41,594 Injury, 78,032 PDO, 120,282 Total

Background

JUL 5, 2016 @ 05:50 PM 1,634 VIEWS

U.S. Traffic Deaths Up In 2015 -- Is There A Se

Cheryl and Christopher Jensen
CONTRIBUTOR

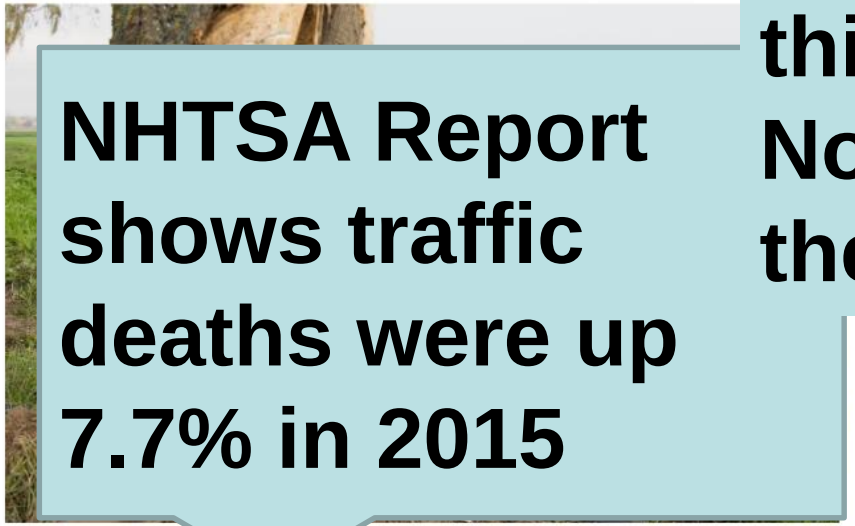
We report on auto tech and consumer and safety issues

FULL BIO >

Opinions expressed by Forbes Contributors are their own.

By Cheryl Jensen

It looks like projections earlier this year about an increase in motor ve deaths could, unfortunately, become fact.



JULIAN STRATENSCHULTE/AP

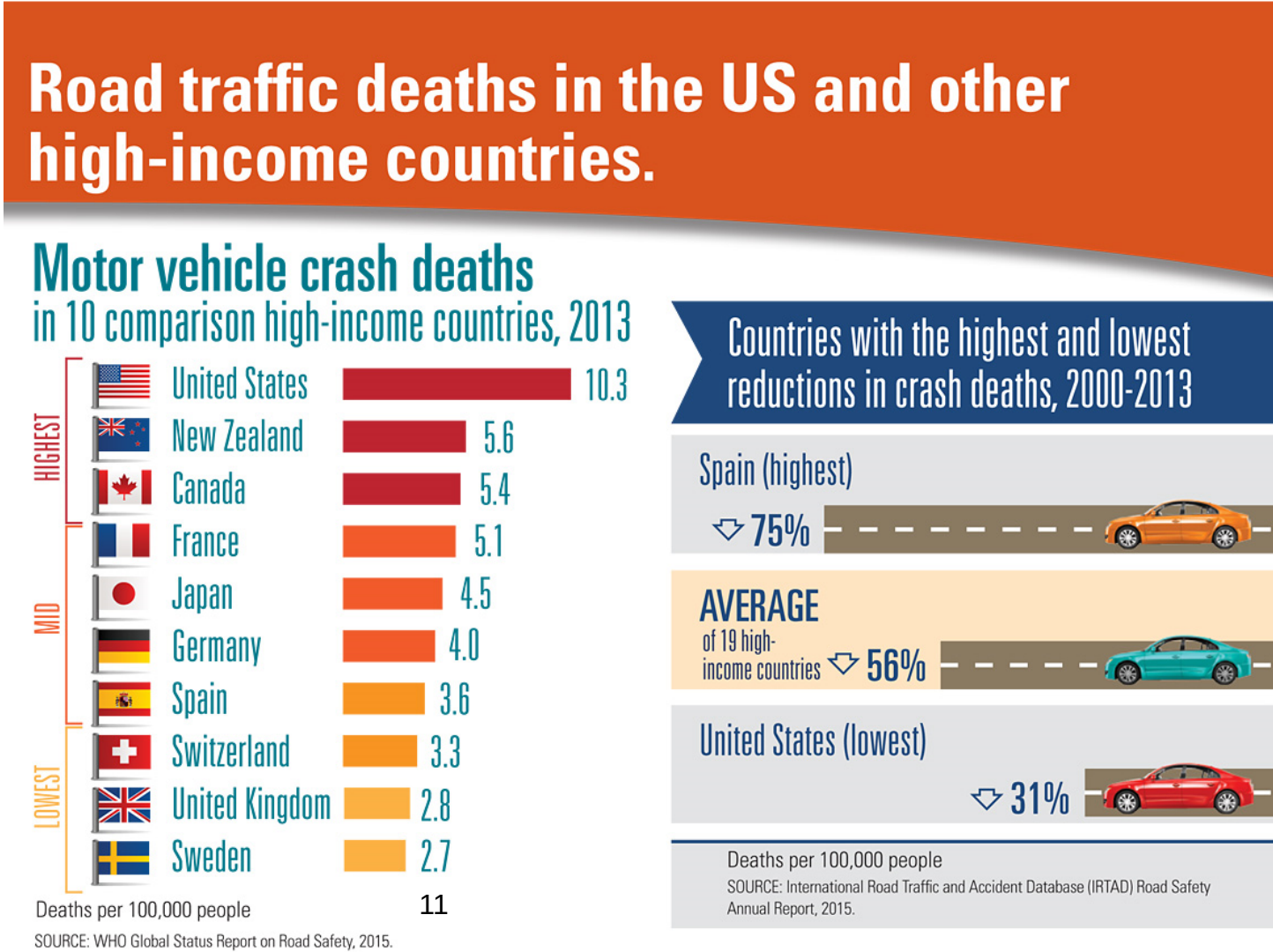
Preliminary data from the federal government's National Highway Traffic Safety Administration (NHTSA) just released show traffic deaths were up 7.7% in 2015.

NHTSA Report shows traffic deaths were up 7.7% in 2015

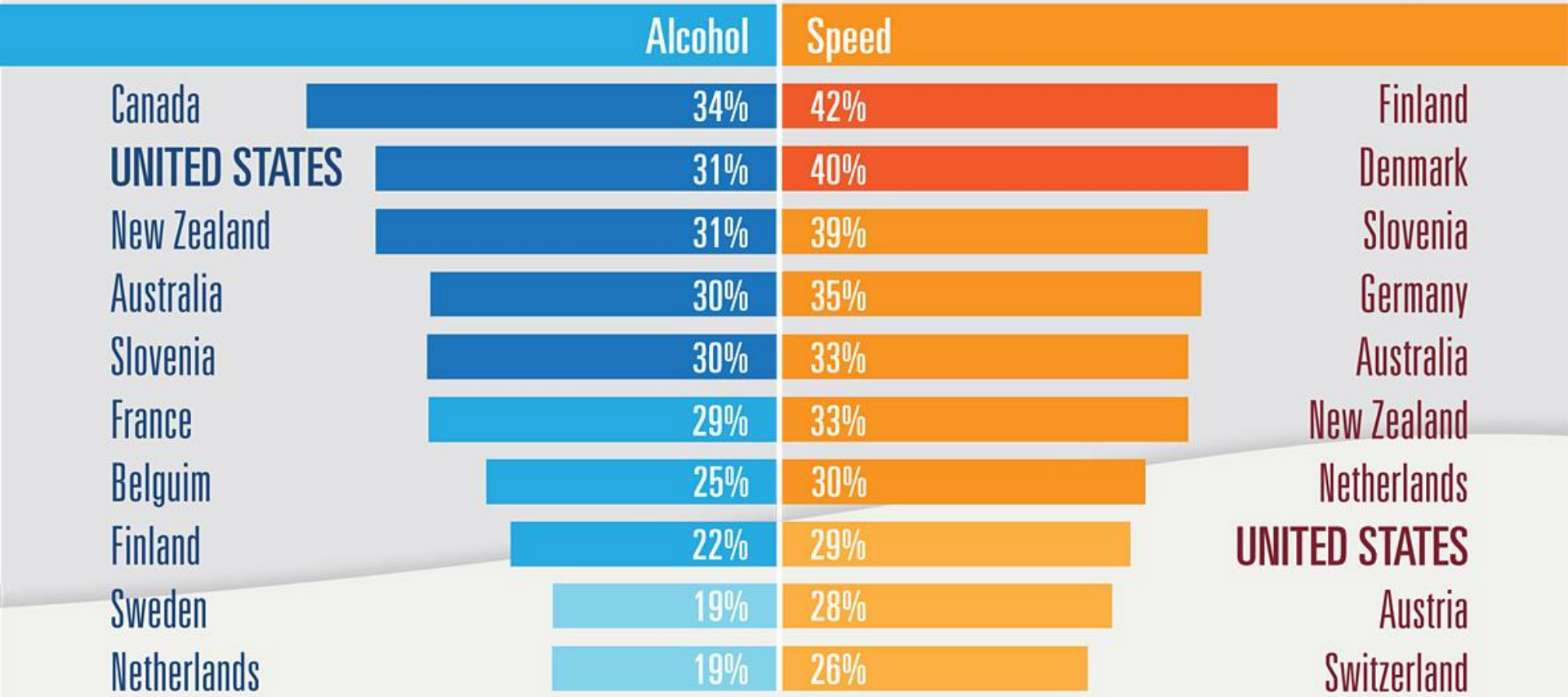
Complacency: Satisfied with how things are & Not wanting to make them better

CDC 7/6/2016

- Motor vehicle crash fatalities in the U.S. *could drop by half with proven strategies*
- Lower death rates in high-income comparison countries suggest that progress is possible



High-income countries with the highest percentage of crash deaths involving alcohol or speed



Note: 19 countries reported the percentage of deaths involving alcohol and 15 countries reported the percentage of deaths related to speeding.

SOURCES: WHO Global Status Report on Road Safety, 2015. IRTAD Road Safety Annual Report, 2015.

Background

Problem	Recommendation
In the US, belt use was lower than in most other countries (9,500 fatalities)	Use a seat belt in every seat, on every trip, no matter how short. Children back seat car seat, booster seat, or seat belt, for appropriate height, age, and weight.

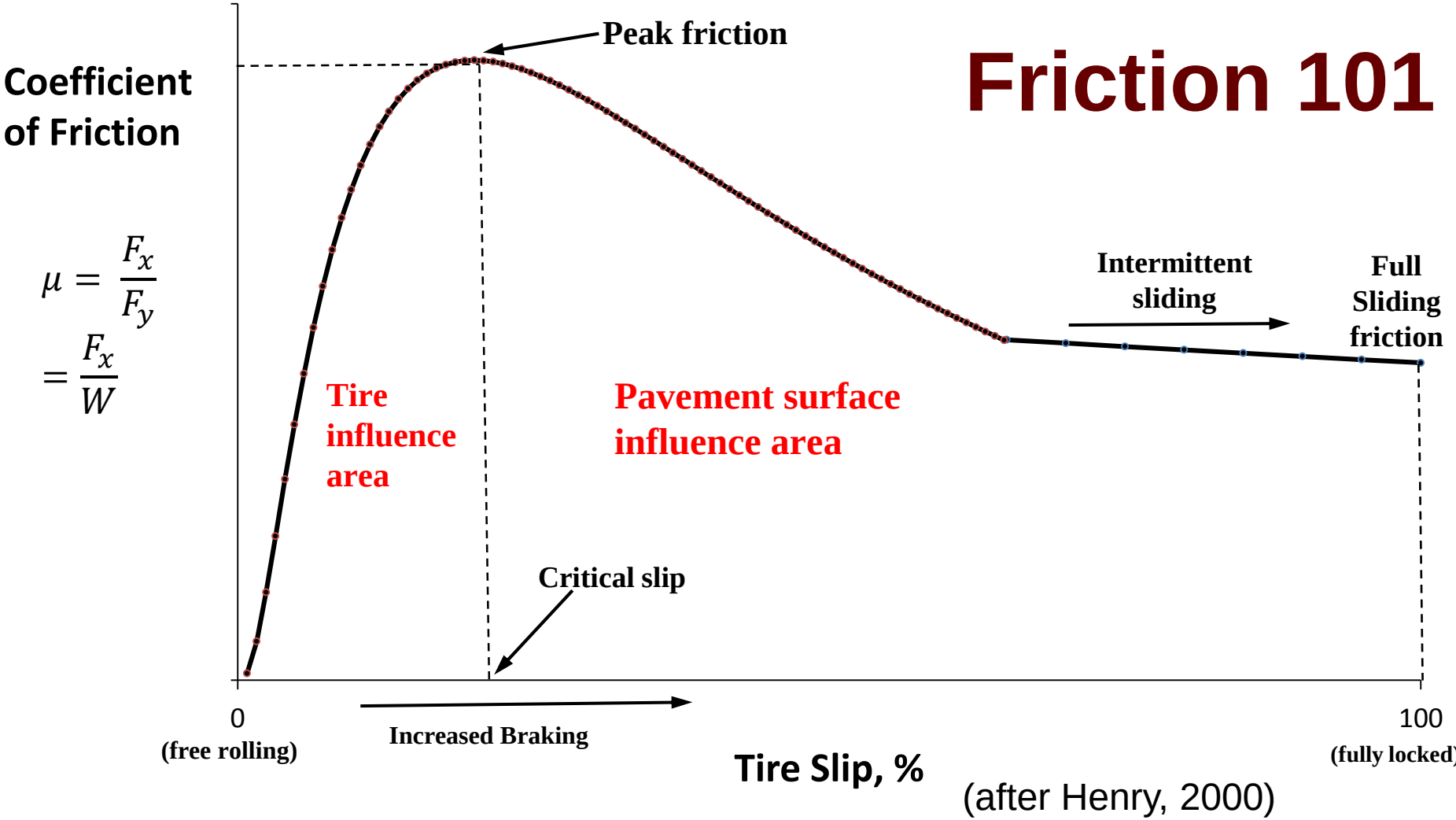
CDC Conclusions

Problems	Recommendation
Not using seat belt	Use seat belts
Drunk/impaired driving	Don’t drink and drive
Speeding	Don't drive over the limit
Distracted driving	Don't text, call, or be distracted when driving

Background: But, what can *we* do?

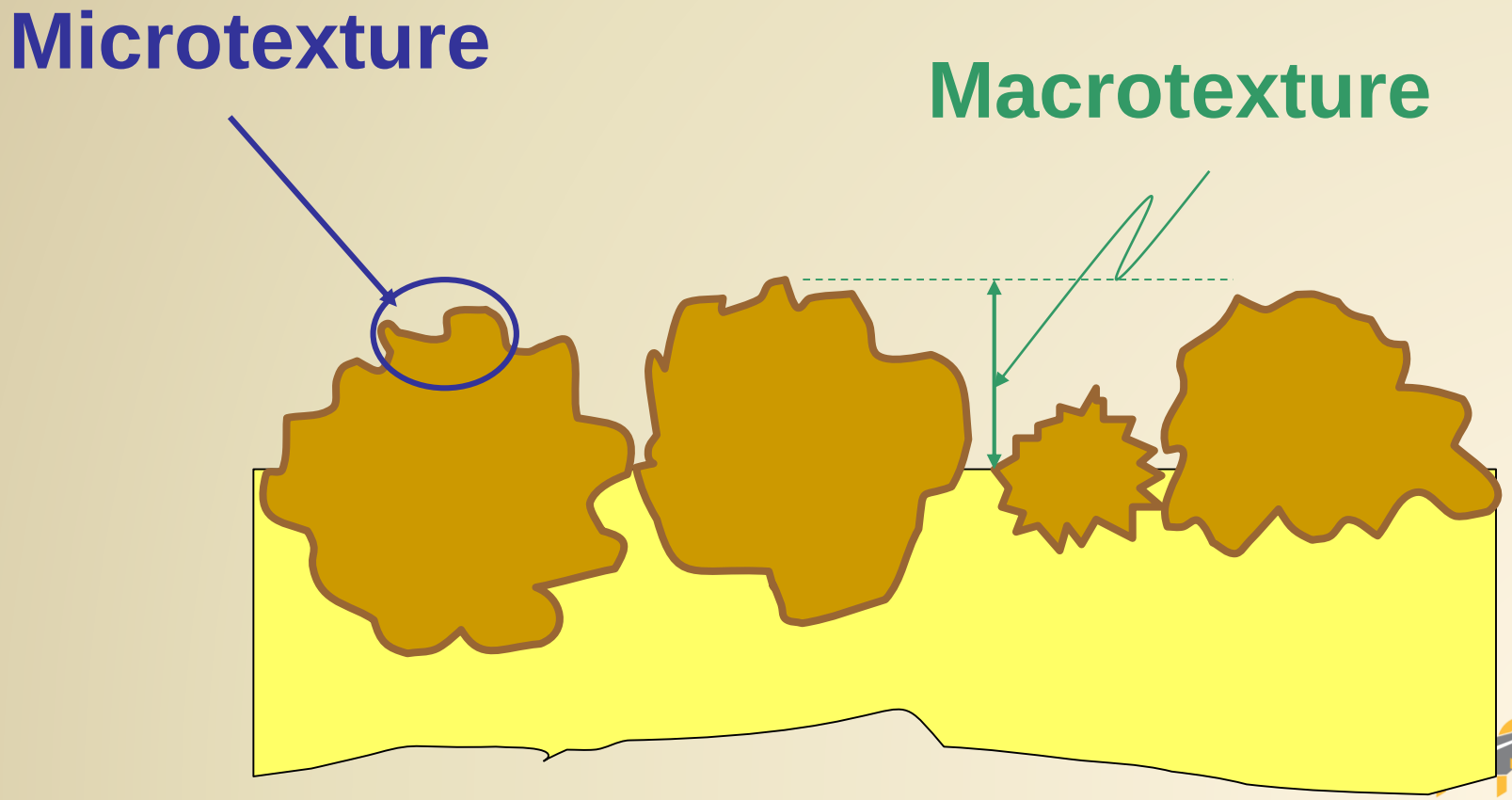
1. We can improve the friction of the roads (Maintenance)
2. We can determine where to improve friction with crash data analysis (Safety)
3. We can specify how and when to improve friction (Materials)

Friction 101

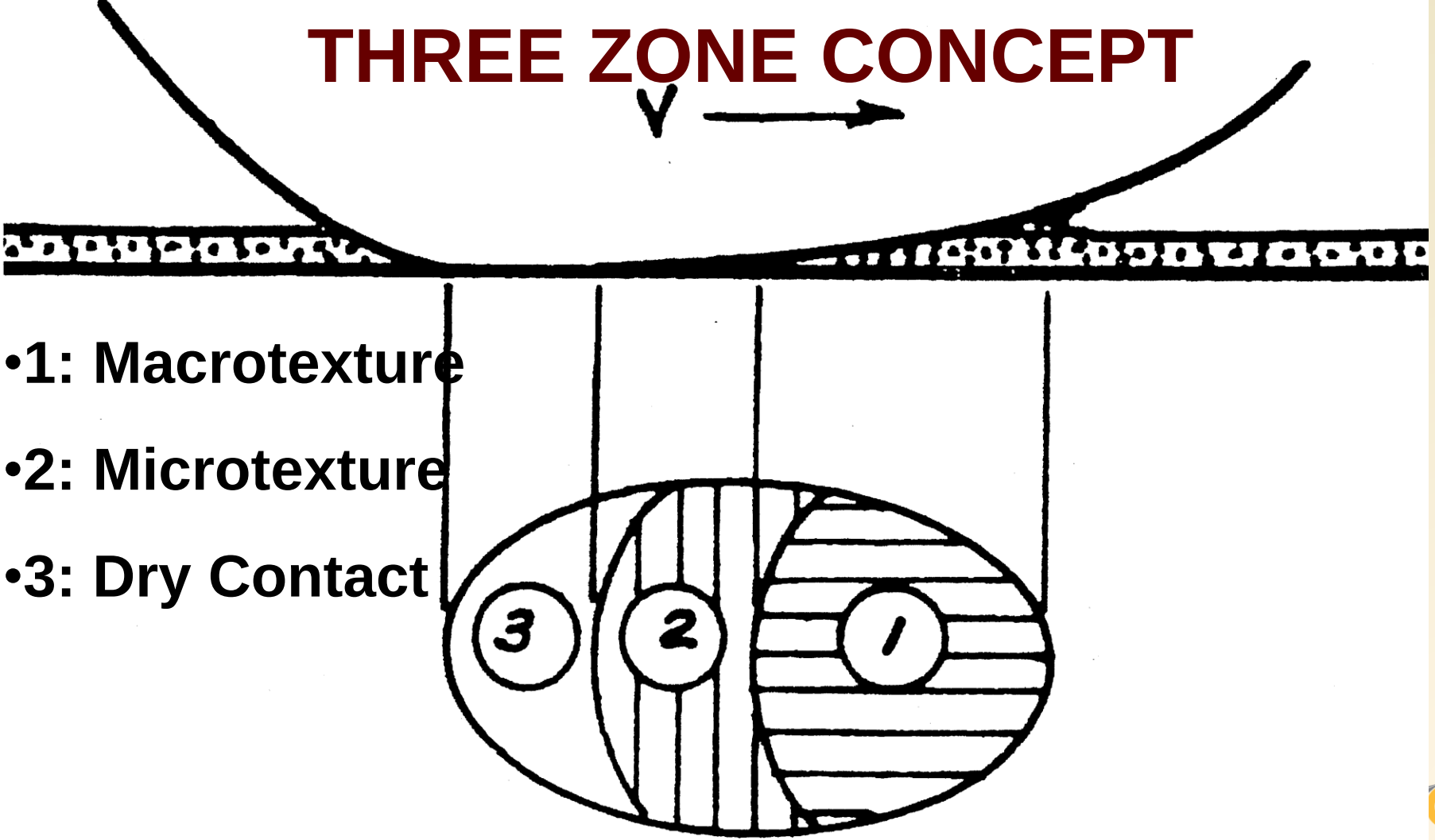


(after Henry, 2000)

Friction 101: What is texture?



THREE ZONE CONCEPT



- 1: Macrotexture
- 2: Microtexture
- 3: Dry Contact

Guide for Pavement Friction, p.62

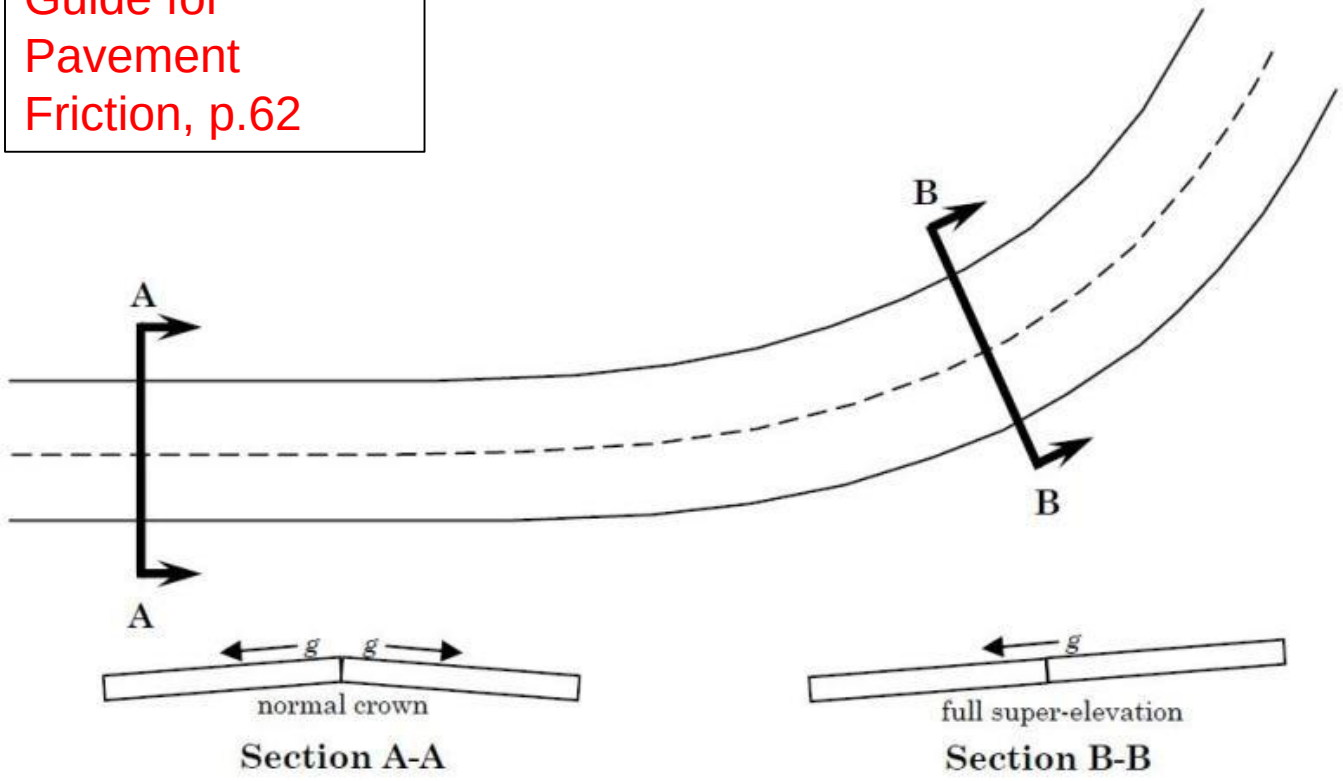


Figure 27. Change in highway cross-section as the horizontal alignment transitions from a tangent to a curve.

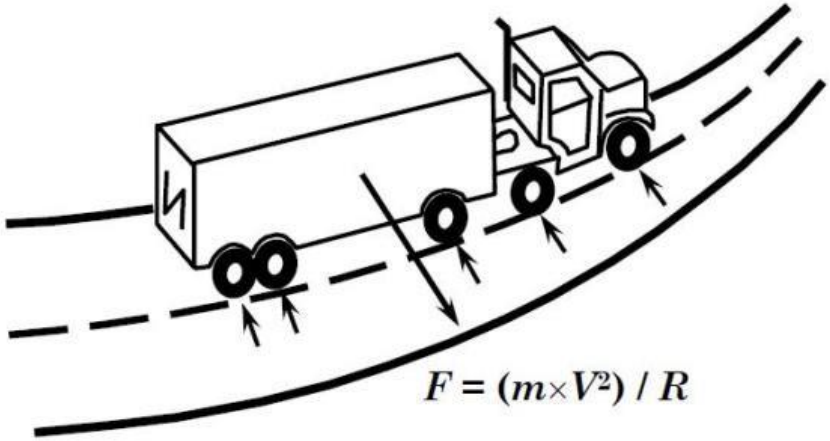


Figure 28. Lateral forces that act on a vehicle as it travels along a curve.

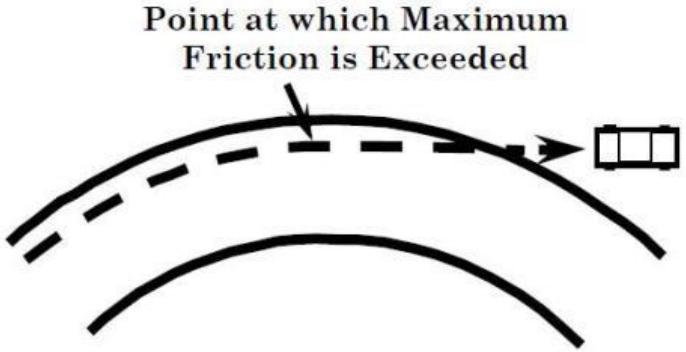
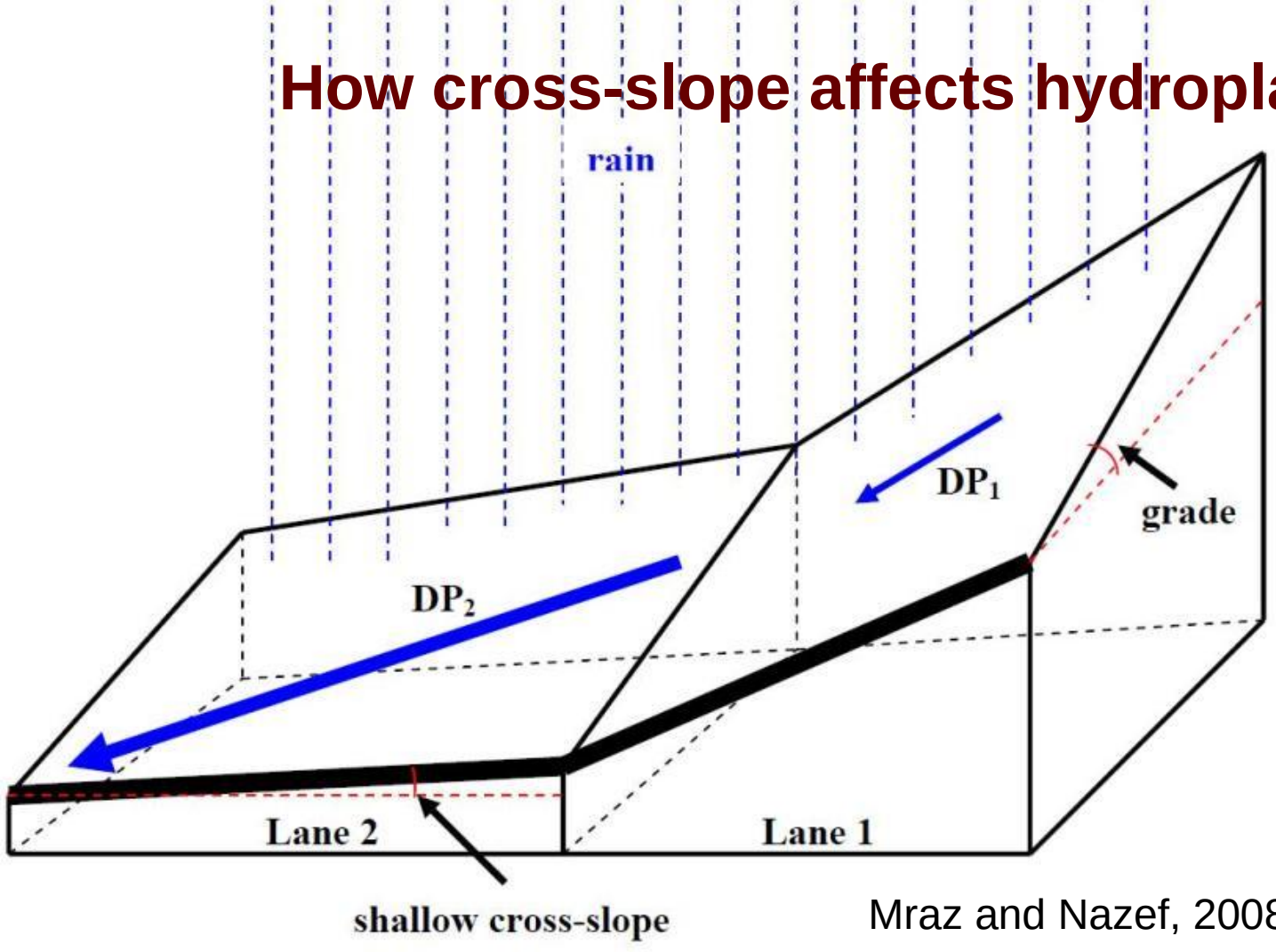


Figure 29. Lateral sliding.

$$f + e = \frac{V_c^2}{15R}$$

Guide for Pavement Friction, p.62 (cont.)

How cross-slope affects hydroplaning



Mraz and Nazef, 2008

Friction 101: test tire

Virginia Transportation

Tires used in the US

ASTM E-501, E-524, E-1551, & E1844

Acceptance Testing and Demonstration of CFME:

- **Goal: reduce highway crashes and related fatalities**
- **Evaluate the recommendations 2008 AASHTO: Guide for Pavement Friction**

CFME: Continuous Friction Measurement Equipment

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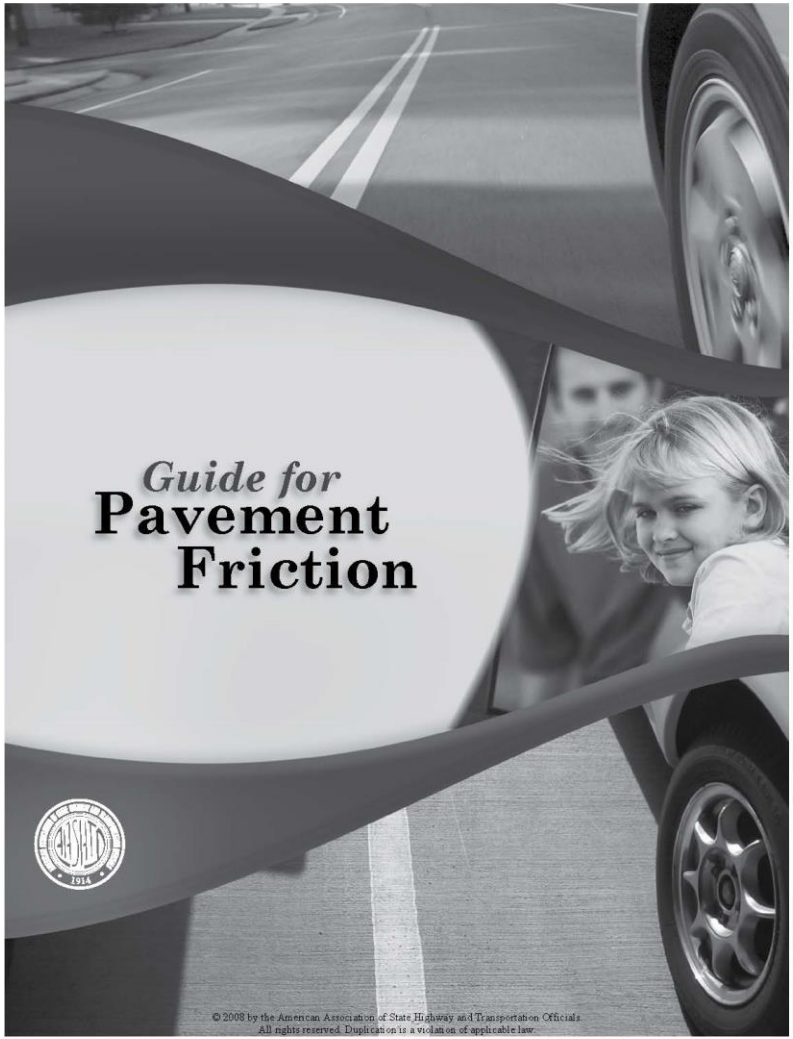


Acceptance Testing and Demonstration of CFME:

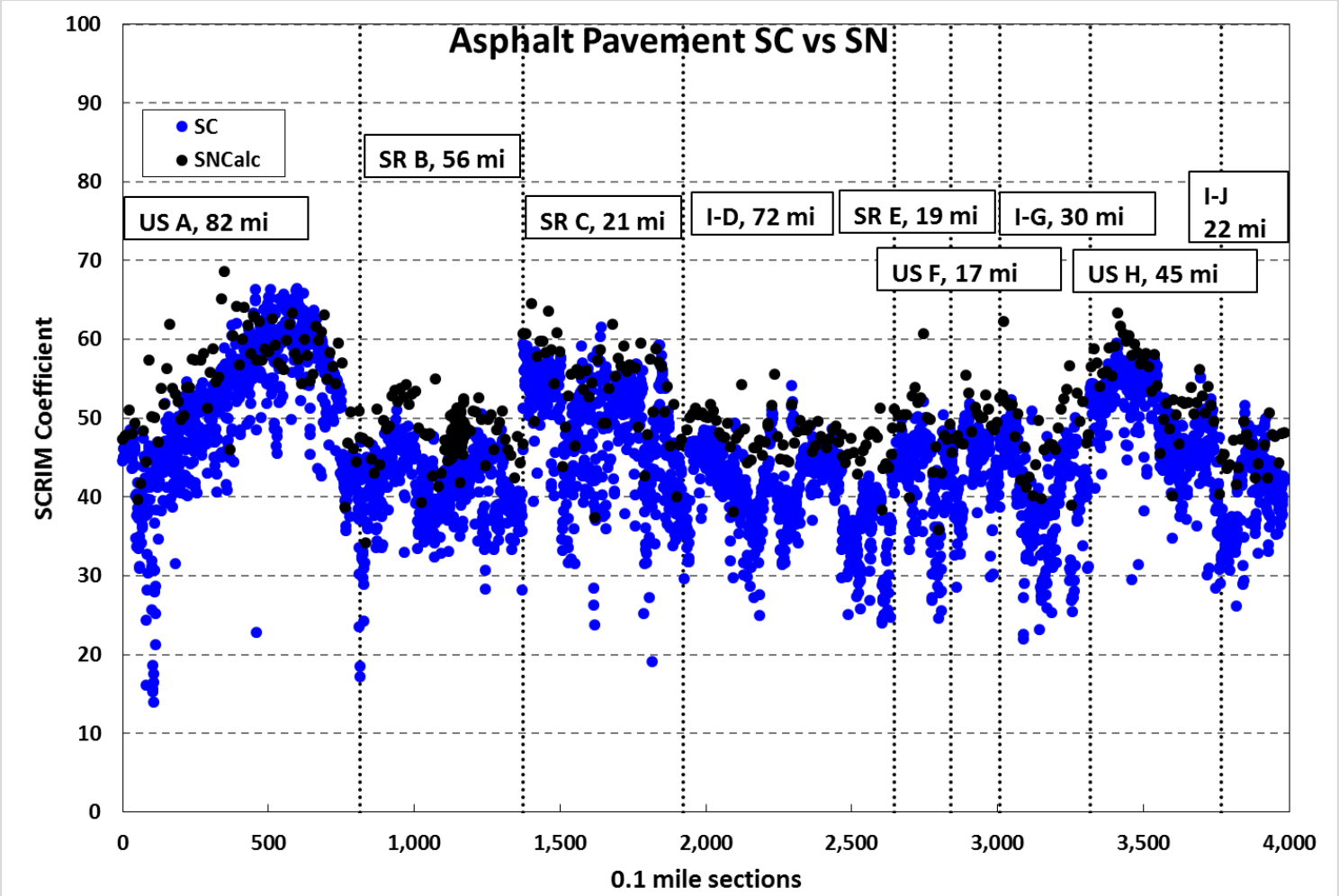
- **Assist 4 states develop Pavement Friction Management Programs (using pavement friction, texture*, crashes, and other data)**
- **Develop and demonstrate methods**
  - **Get friction, texture, crash, traffic, other data**
  - **Define friction demand categories**
  - **Set investigatory levels of friction/texture**

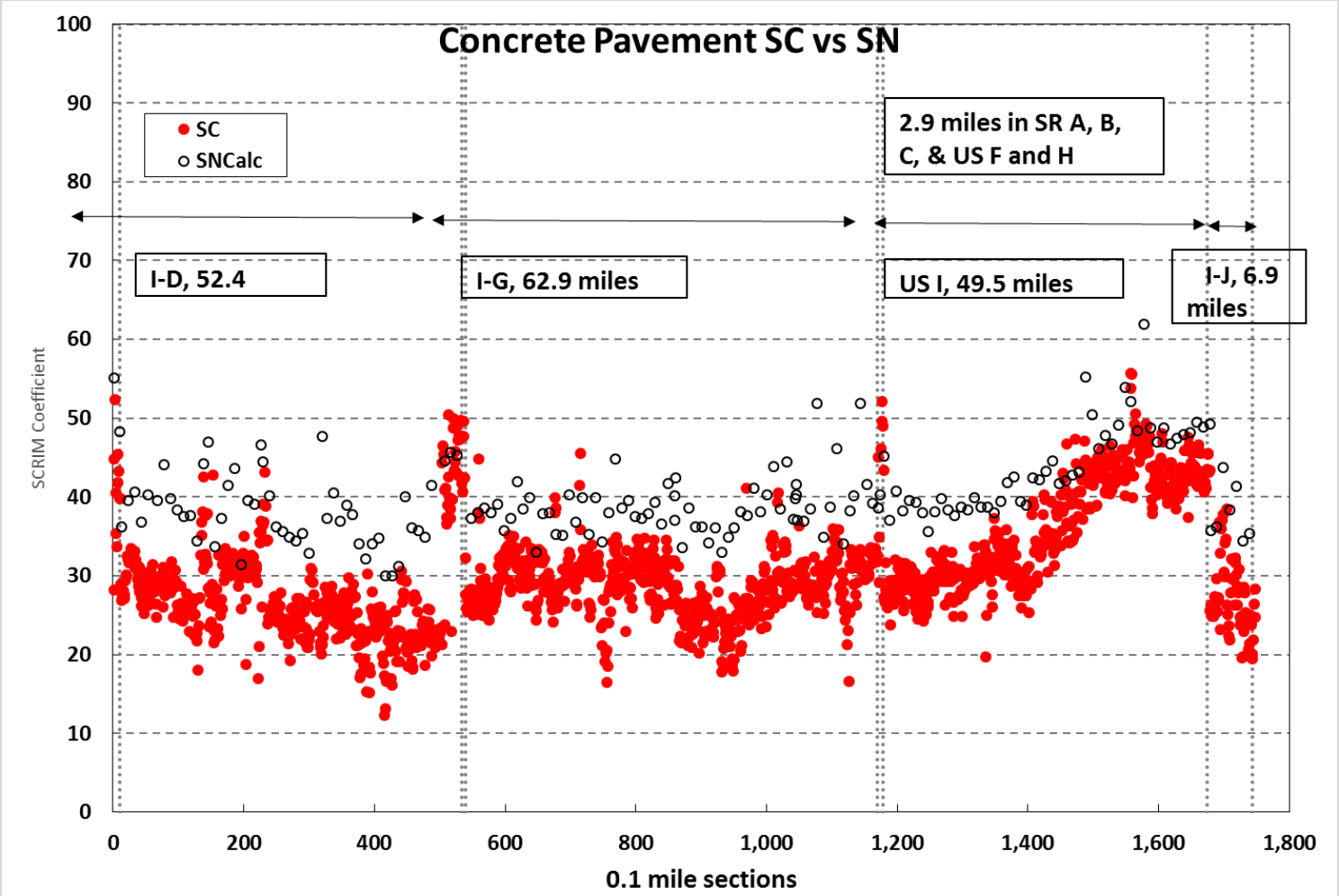
*Texture = macrotexture

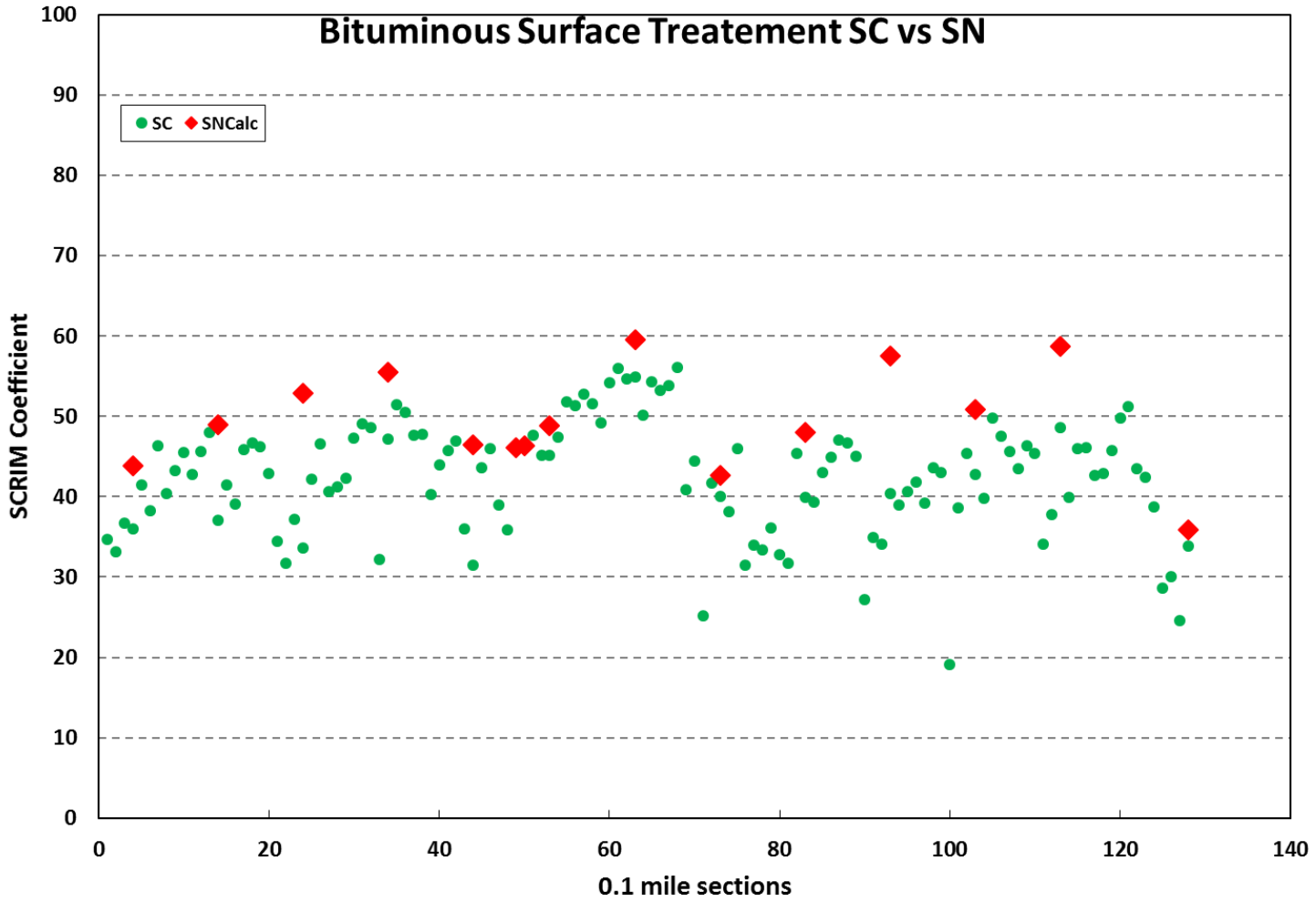
Acceptance Testing and Demonstration of CFME:

- **Washington** **575 miles**
- **Florida** **875 miles**
- **Indiana** **875 miles**
- **Texas** **840 miles**

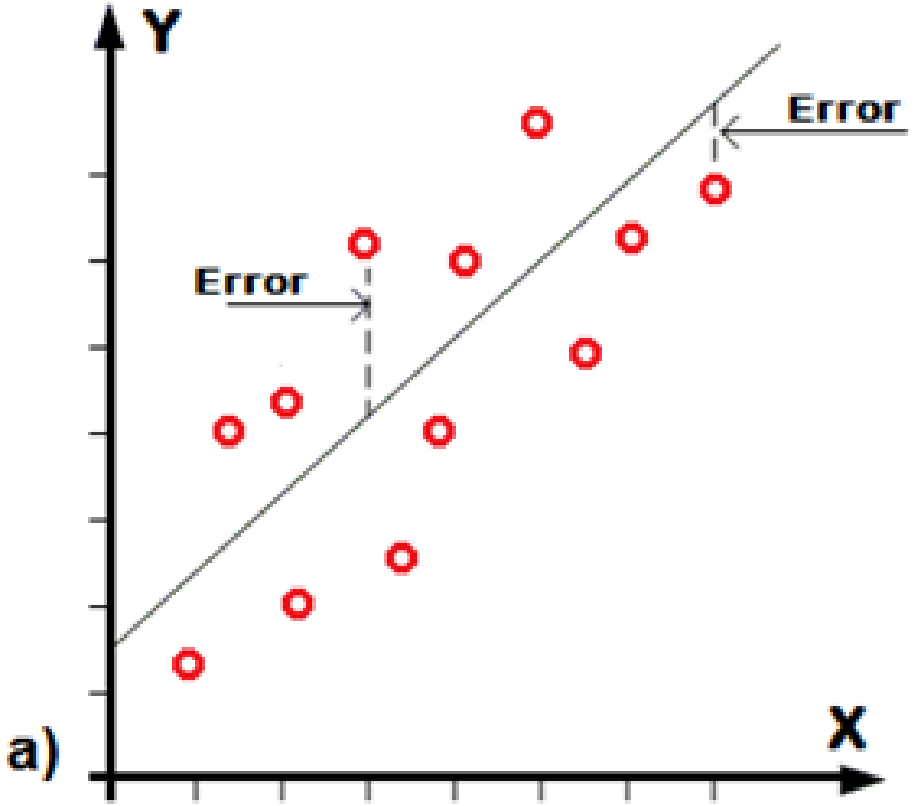
- **North Carolina** **±500 miles**

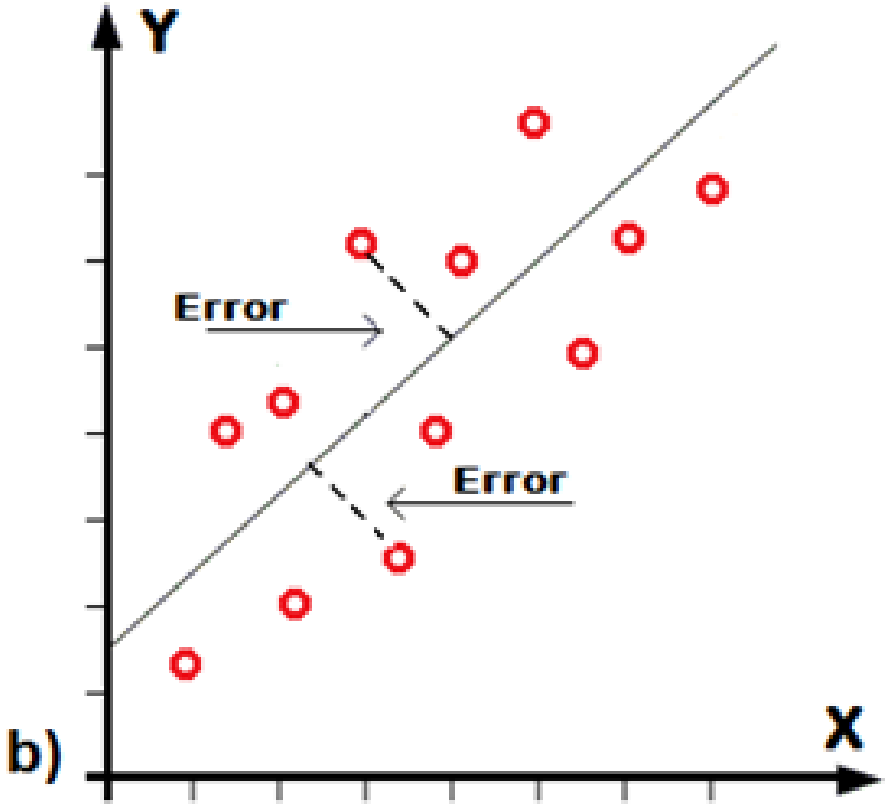

Asphalt Pavement SC vs SN
SC
SNCalc
US A, 82 mi
SR B, 56 mi
SR C, 21 mi
I-D, 72 mi
SR E, 19 mi
I-G, 30 mi
I-J
22 mi
US F, 17 mi
US H, 45 mi
SCRIM Coefficient
0.1 mile sections
0
10
20
30
40
50
60
70
80
90
100
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000

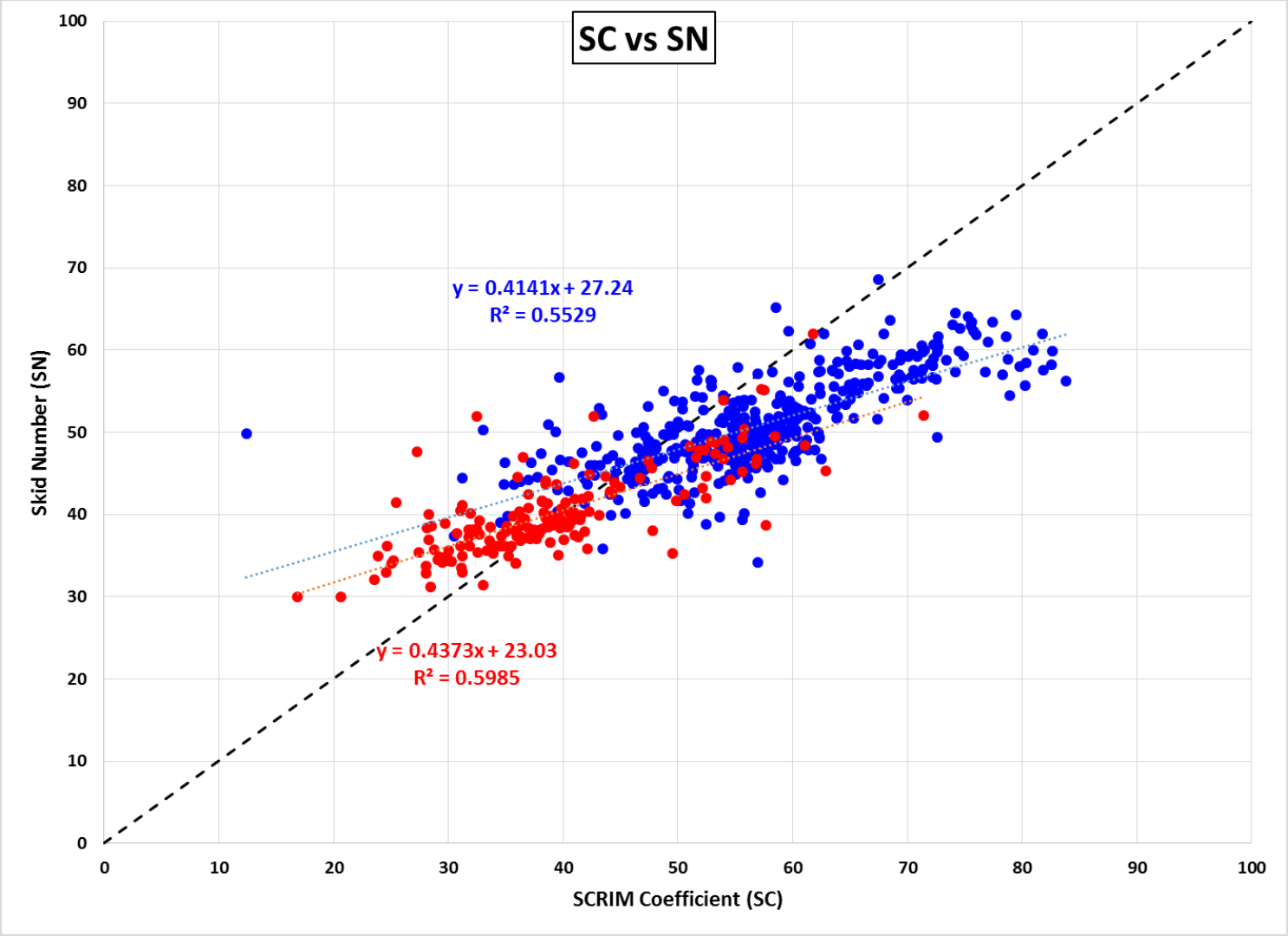

Concrete Pavement SC vs SN
SC
SNCalc
2.9 miles in SR A, B, C, & US F and H
I-D, 52.4
I-G, 62.9 miles
US I, 49.5 miles
I-J, 6.9 miles
SCRIM Coefficient
0.1 mile sections
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800


Bituminous Surface Treatement SC vs SN
SC
SNCalc
SCRIM Coefficient
0.1 mile sections
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140

Statistical Analysis: Regression






SC vs SN
y = 0.4141x + 27.24
R² = 0.5529
y = 0.4373x + 23.03
R² = 0.5985
Skid Number (SN)
SCRIM Coefficient (SC)
0
10
20
30
40
50
60
70
80
90
100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Crash analysis

Do we need the same friction everywhere?

- **Minimum friction (VA: SN 40S = 20)**
- **Perera et. al. Skid Crash Reduction Programs – Synthesis (MN SN 40R):**
  - **Interstate: 28-41**
  - **Primary: 25-37**
  - **Secondary: 22-37**


PENSKE


45


749
READ VALLEY

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

(US-English)

Road classification definitions		Investigatory level 30 mph							
		0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
A	Interstate highways								
B	Divided highways-no event								
C	Two lane road-no event								
Q	Approaches to Intersection (& roundabouts)								
K	Pedestrian crossings and other high risk areas								
R	Roundabout								
G1	Slope 5-10%, longer than 160 feet								
G2	Slope >10% longer than 160 feet								
S1	Curve radius < 1600 feet - divided roads								
S2	Curve radius < 1600 feet - two lane roads								

Safety Performance Function (SPF)

Model: $\lambda_i = e^{\beta_0 + \beta_j X_{ij}}$

λ_i = ***crash rate for the i th segment of roadway***

X_{ij} = ***the value of variable j at the i th road segment***

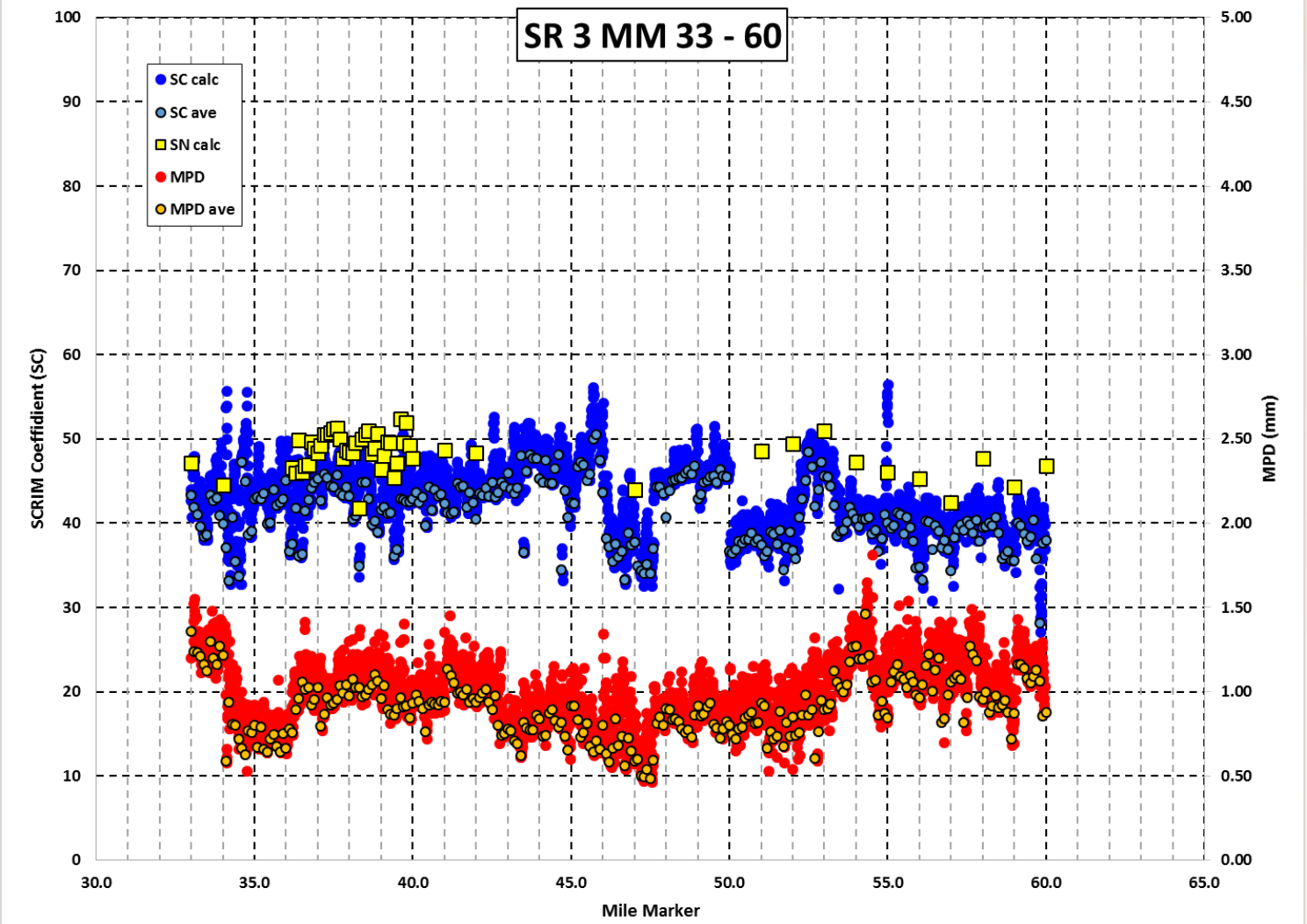
β_j = ***The estimated parameter coefficient for the j th variable*** *(where: j > 0)*

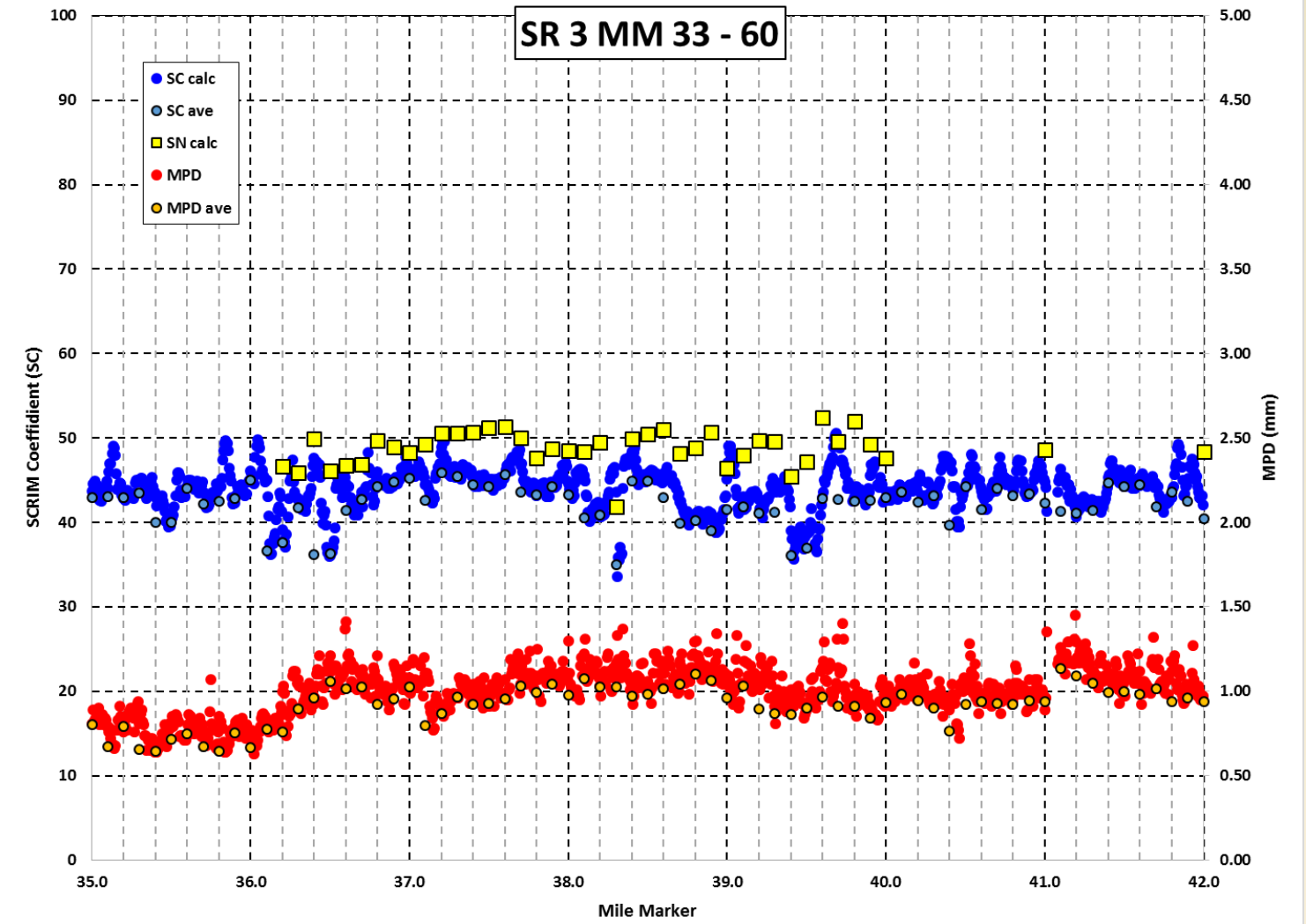
Final Model: crash prediction

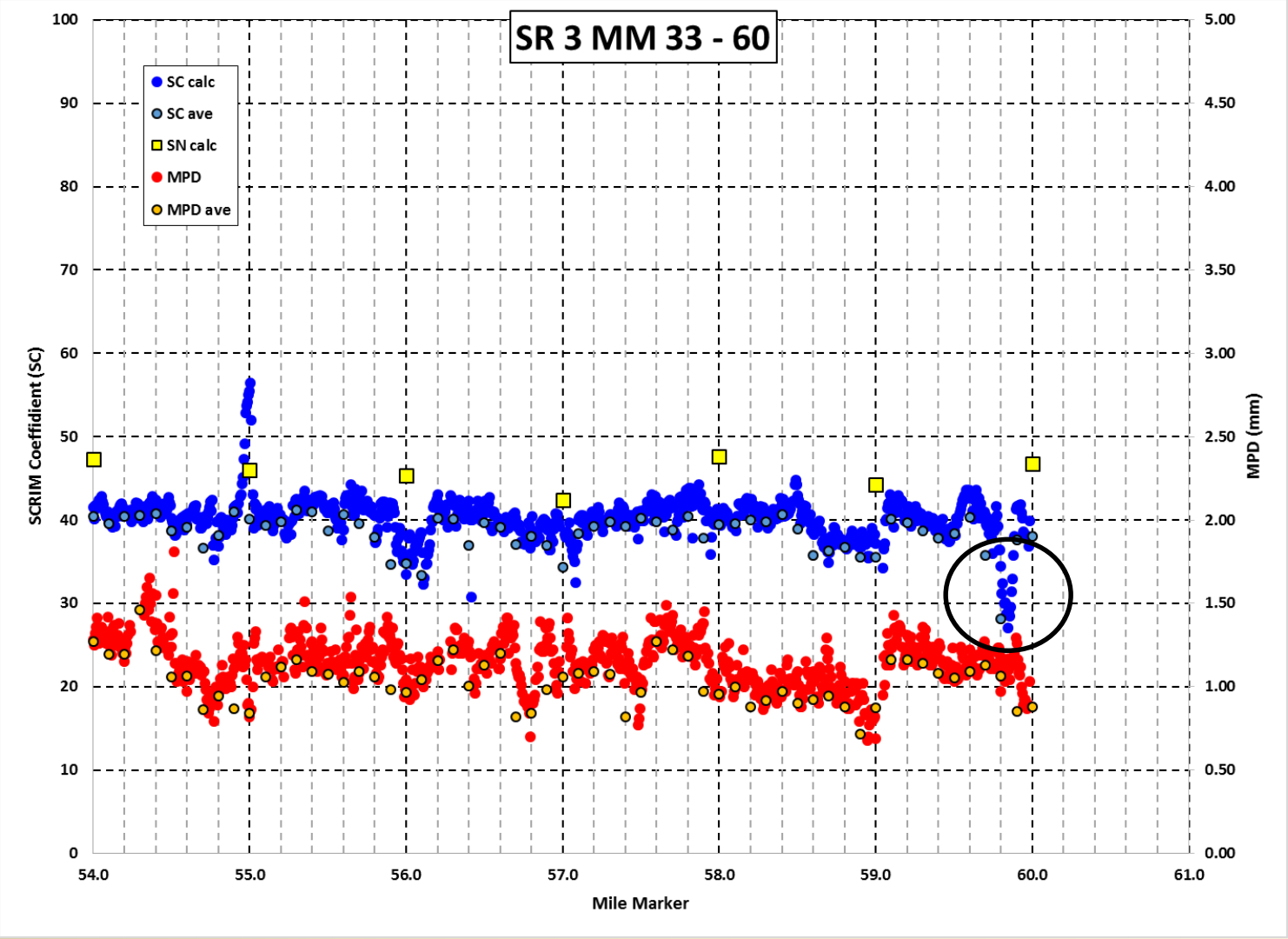
- Combine results of the SPF with EB, .vs.
- Crash Modification Factors: Before/After
- Results in Economic Analysis (B/C) for selected treatments to improve friction and macrotexture at all 0.1 mile sections of network tested

CASE 1

- State Route 3 (MM 59.9)
- 0.1 mile comparison data collection


SR 3 MM 33 - 60
SC calc
SC ave
SN calc
MPD
MPD ave
SCRIM Coeffidient (SC)
MPD (mm)
Mile Marker
100
90
80
70
60
50
40
30
20
10
0
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0

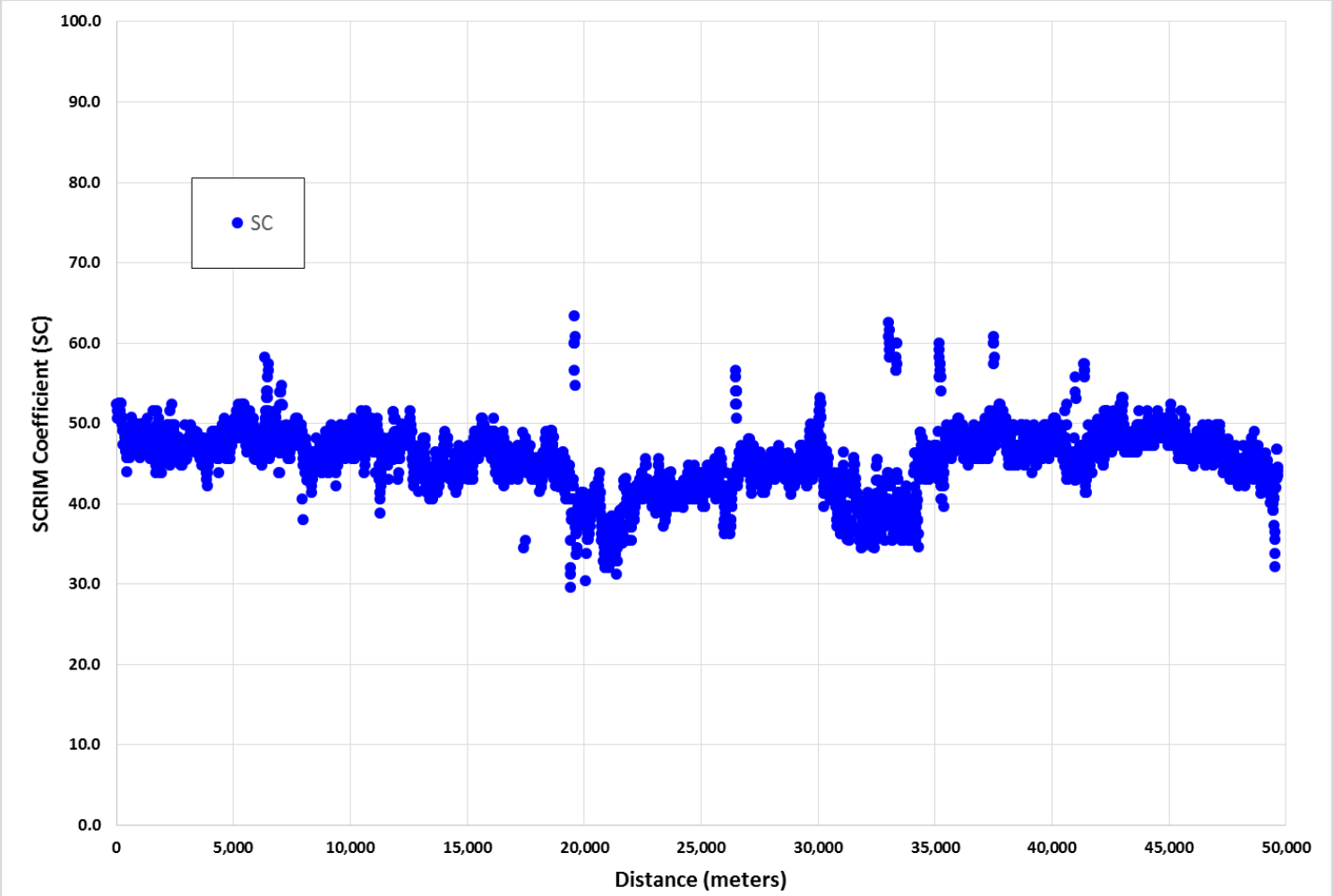

SR 3 MM 33 - 60
SC calc
SC ave
SN calc
MPD
MPD ave
SCRIM Coeffidient (SC)
MPD (mm)
Mile Marker
100
90
80
70
60
50
40
30
20
10
0
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
35.0
36.0
37.0
38.0
39.0
40.0
41.0
42.0

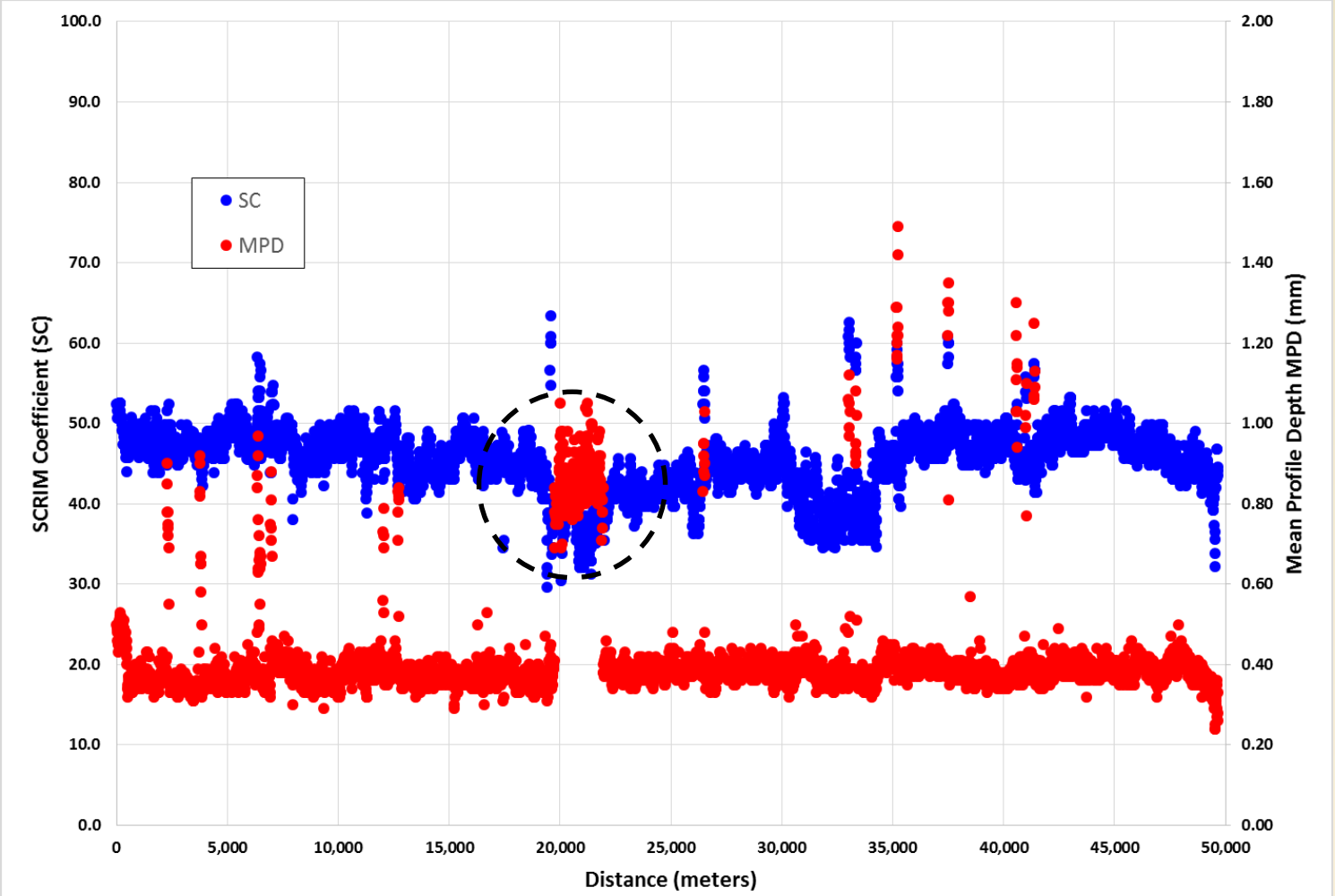

SR 3 MM 33 - 60
SC calc
SC ave
SN calc
MPD
MPD ave
SCRIM Coeffidient (SC)
MPD (mm)
Mile Marker
100
90
80
70
60
50
40
30
20
10
0
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
54.0
55.0
56.0
57.0
58.0
59.0
60.0
61.0


31740

CASE 2

- **Interstate Pavement**
- **Friction and Texture**


100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
SCRIM Coefficient (SC)
SC
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
Distance (meters)


SC
MPD
SCRIM Coefficient (SC)
Mean Profile Depth MPD (mm)
Distance (meters)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000

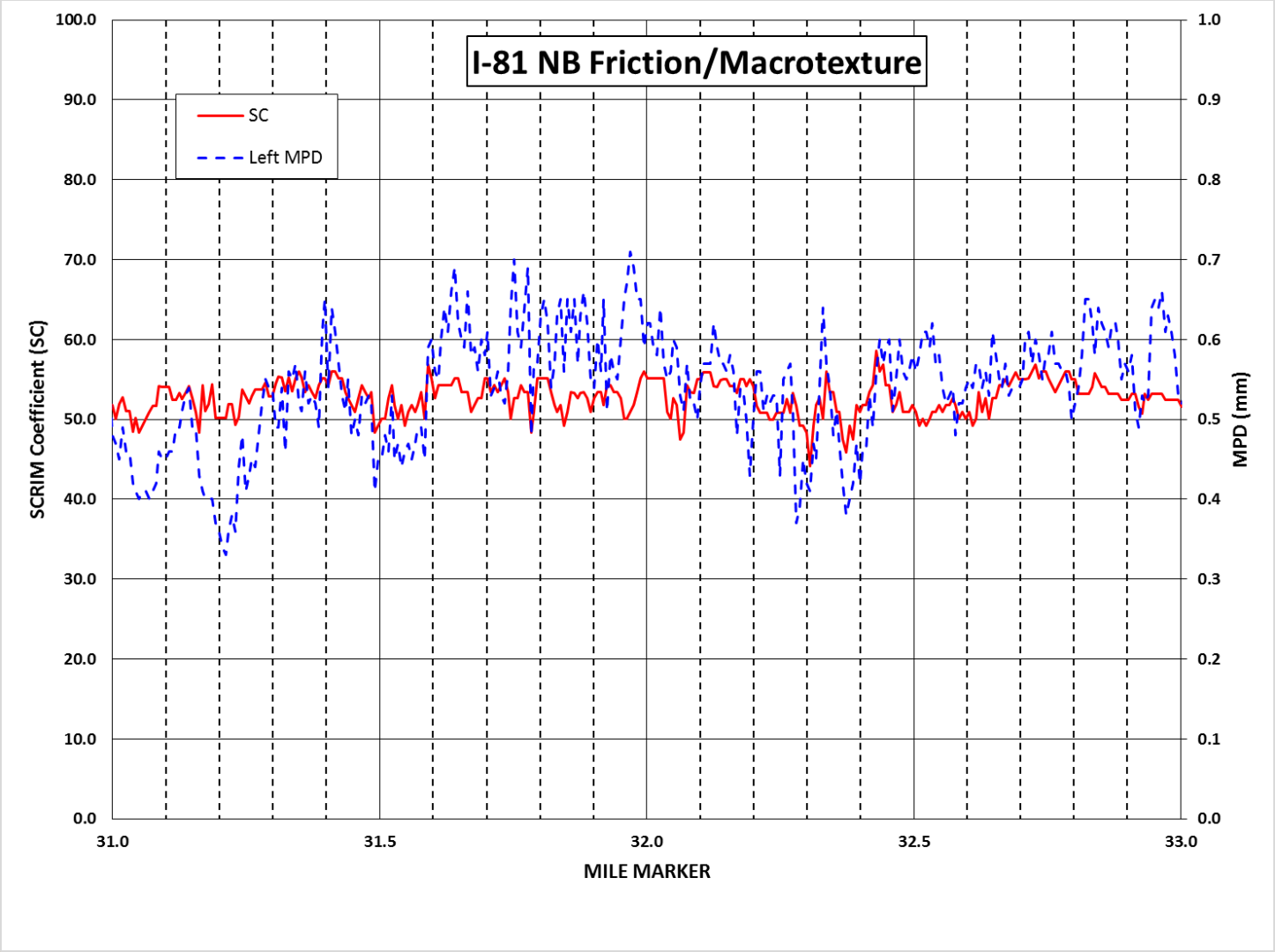
CASE 3

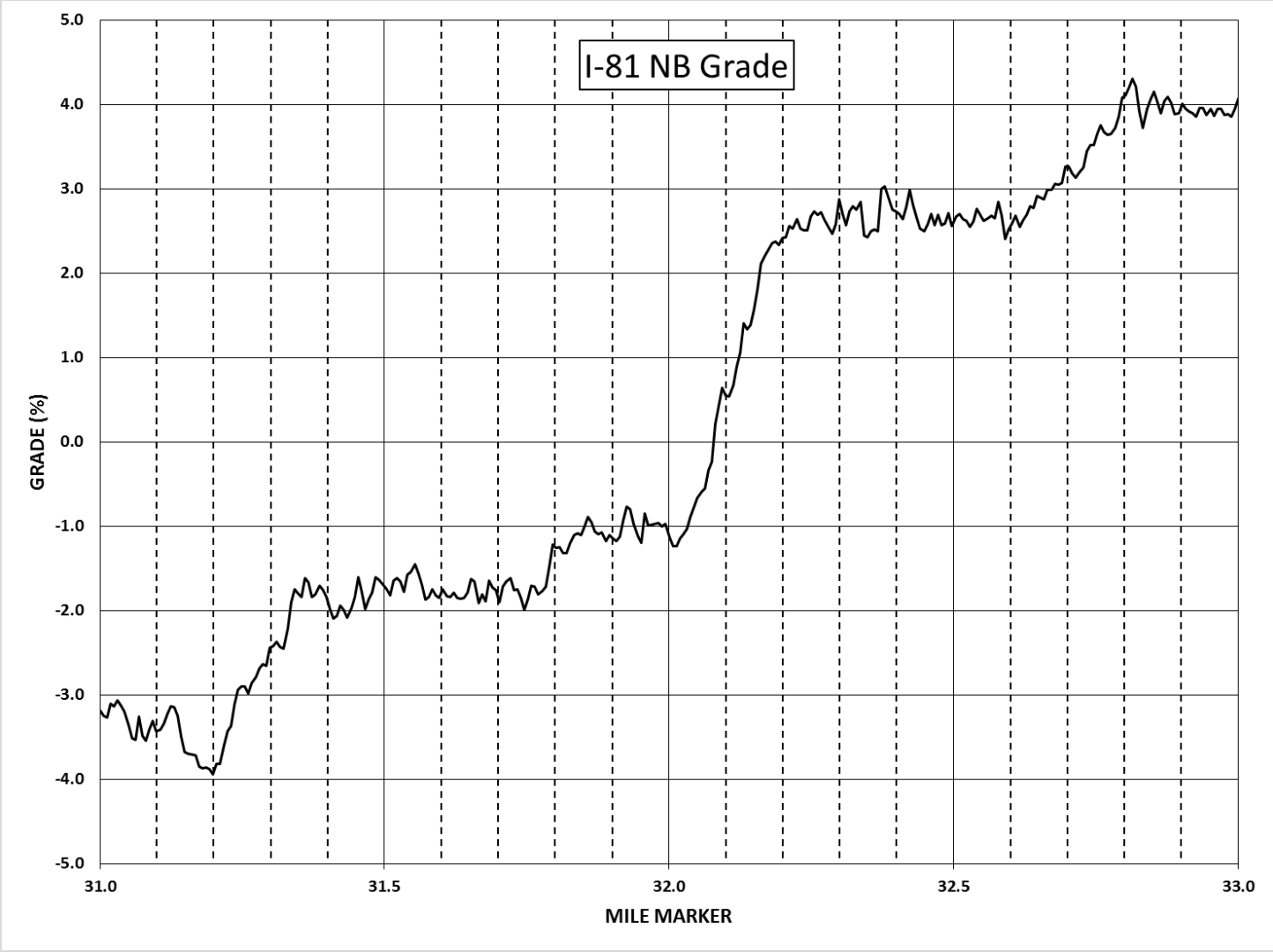
- **Interstate I-81**
- **Friction and Texture**
- **Grade, cross-slope and curvature**

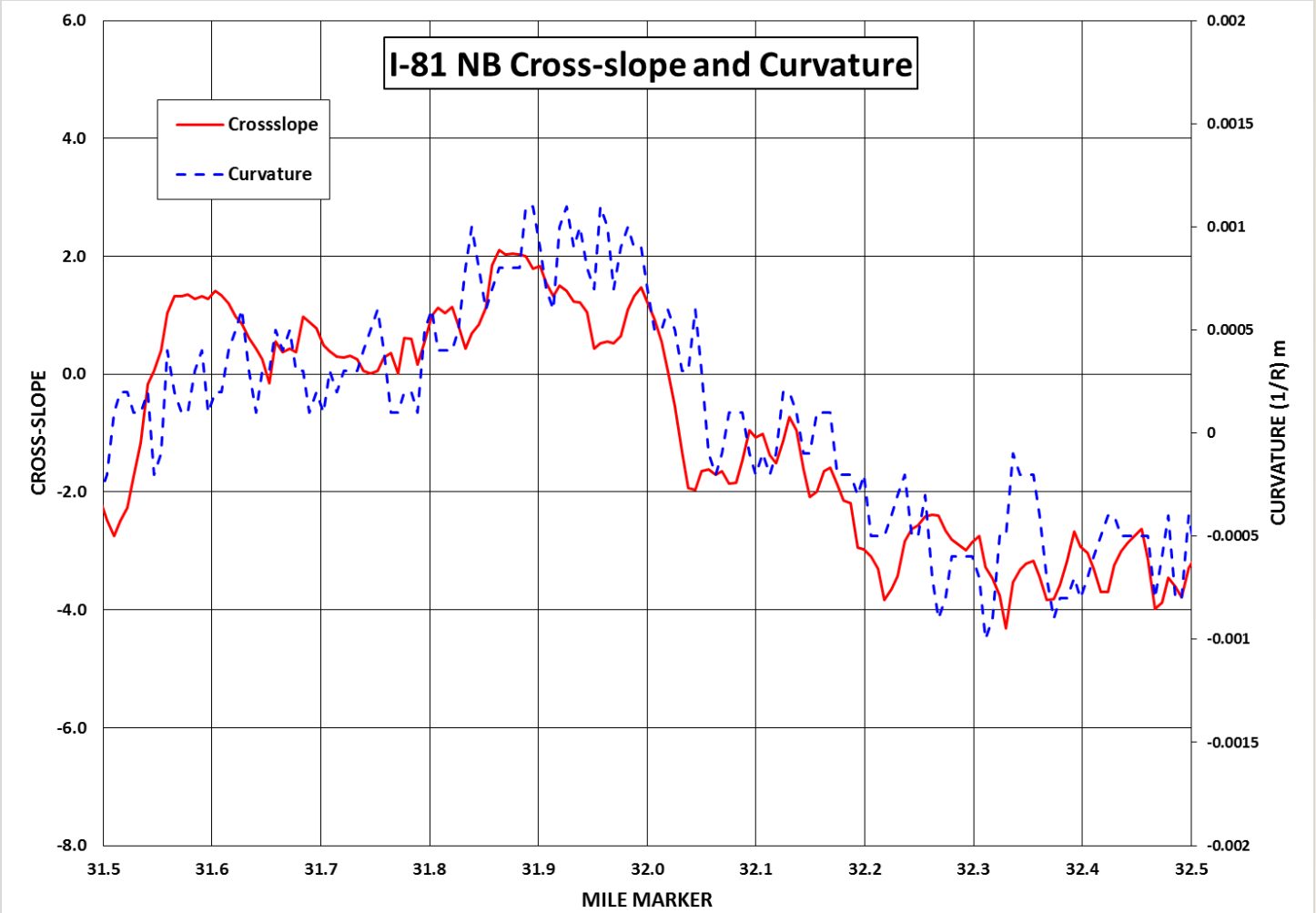

I-81 NB MM 31.5


Chilhowie
I-81 NB MM 31.6

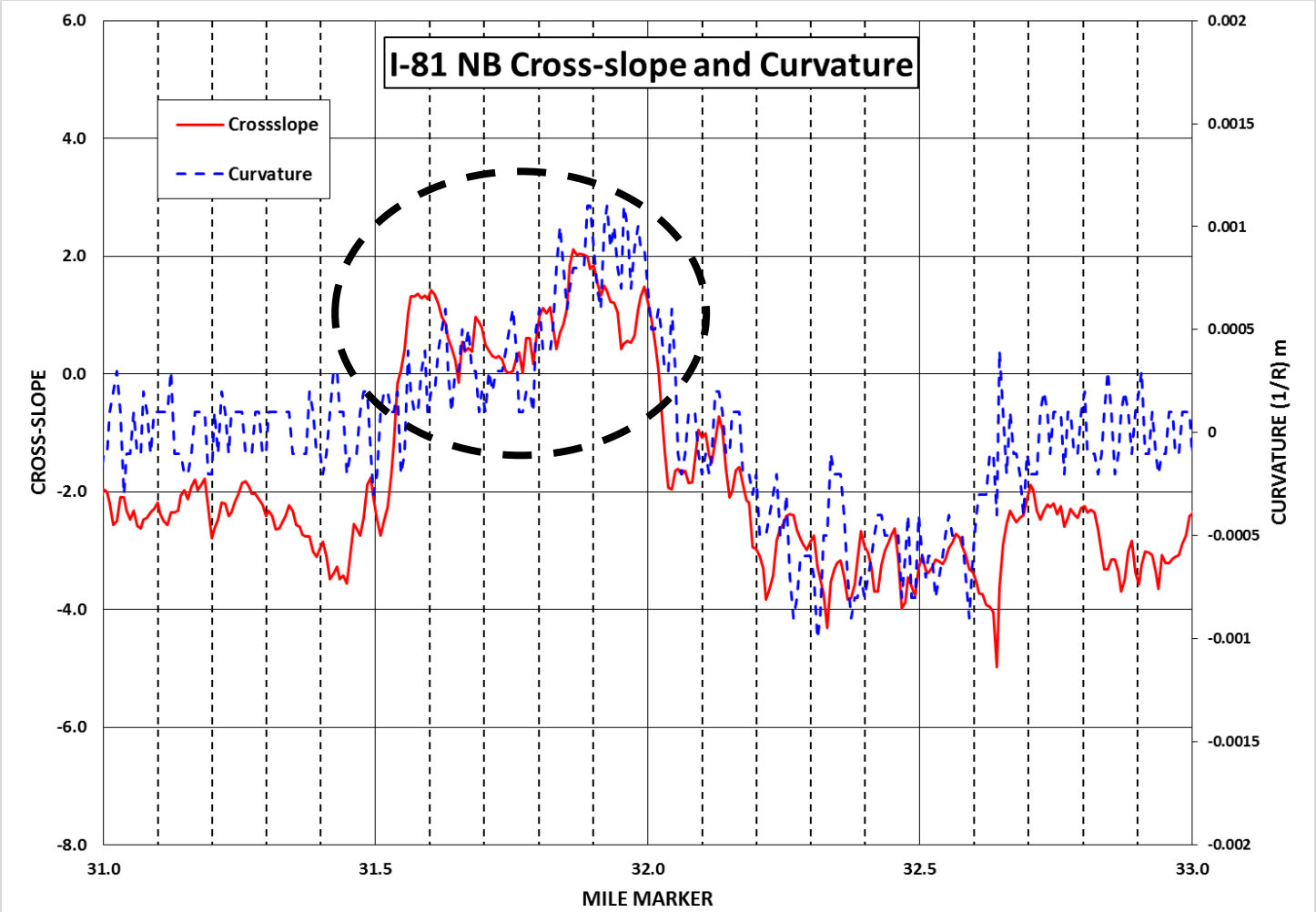

I-81 NB MM 31.7

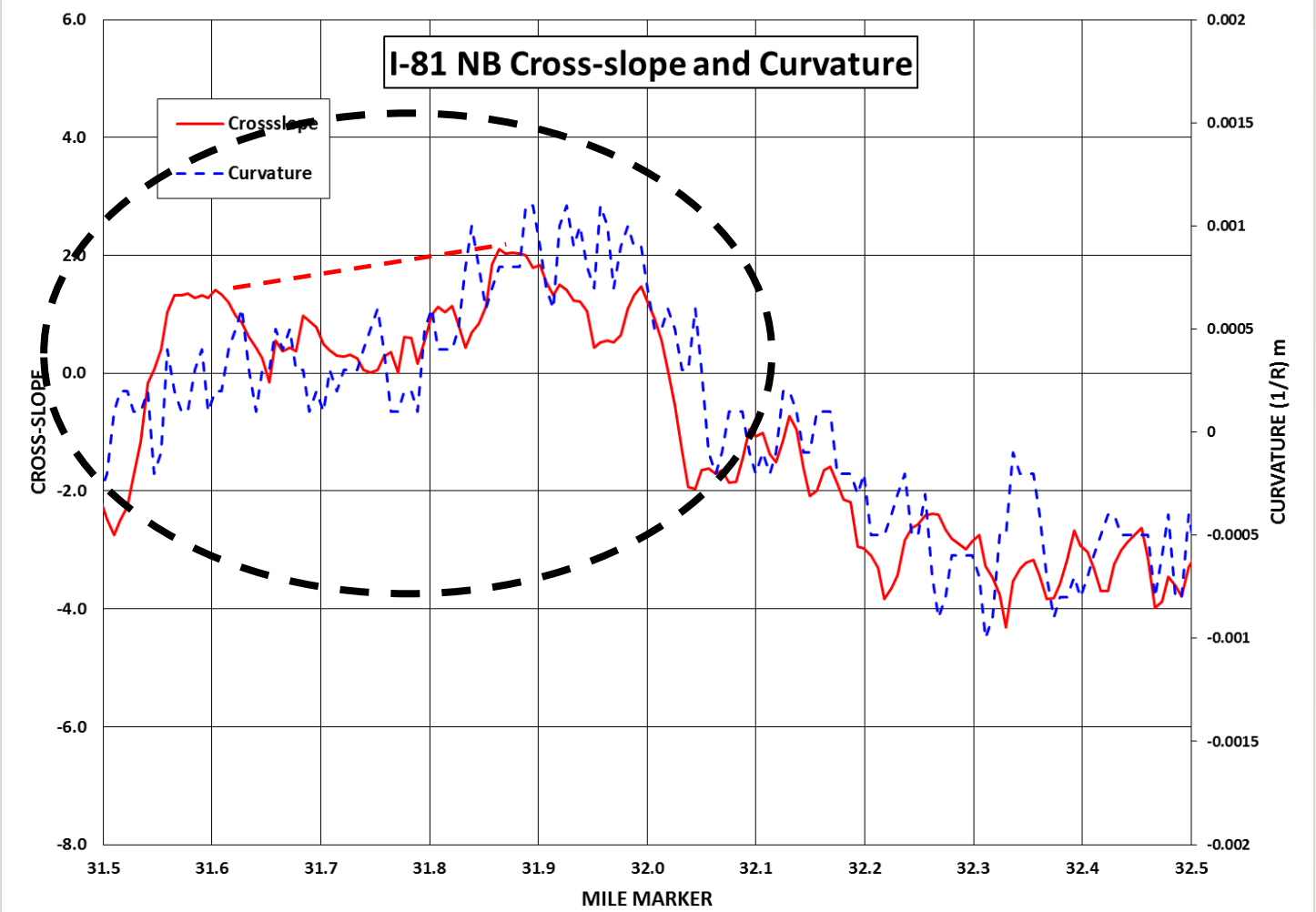

I-81 NB Friction/Macrotexture
SC
Left MPD
SCRIM Coefficient (SC)
MPD (mm)
MILE MARKER
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
31.0
31.5
32.0
32.5
33.0


I-81 NB Grade
GRADE (%)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
31.0
31.5
32.0
32.5
33.0
MILE MARKER


I-81 NB Cross-slope and Curvature
Crossslope
Curvature
CROSS-SLOPE
CURVATURE (1/R) m
MILE MARKER
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
0.002
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
31.5
31.6
31.7
31.8
31.9
32.0
32.1
32.2
32.3
32.4
32.5


I-81 NB MM 31.8

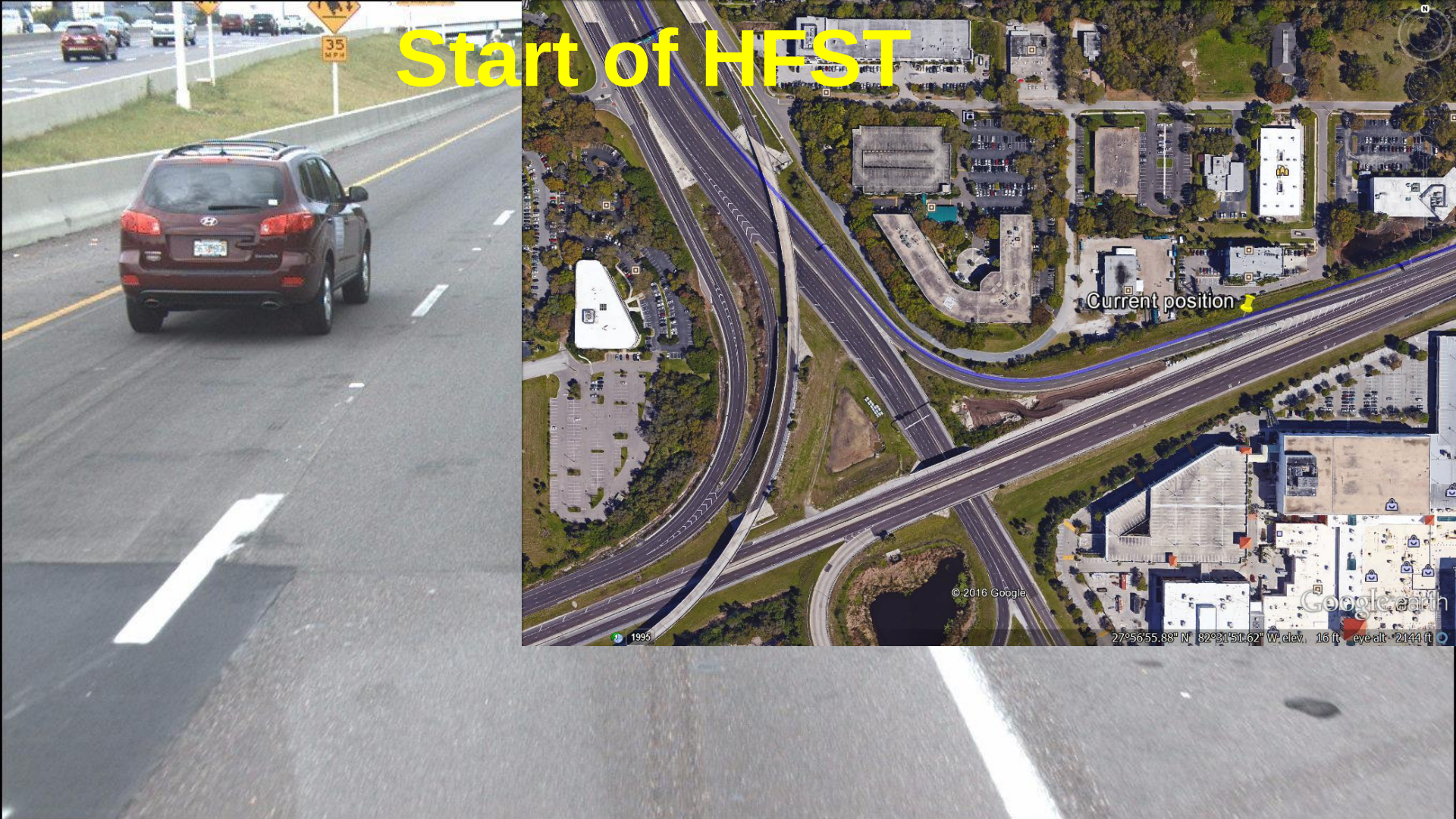

I-81 NB Cross-slope and Curvature
Crossslope
Curvature
CROSS-SLOPE
CURVATURE (1/R) m
MILE MARKER
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
0.002
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
31.0
31.5
32.0
32.5
33.0


I-81 NB Cross-slope and Curvature
Crossslope
Curvature
CROSS-SLOPE
CURVATURE (1/R) m
MILE MARKER
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
0.002
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
31.5
31.6
31.7
31.8
31.9
32.0
32.1
32.2
32.3
32.4
32.5

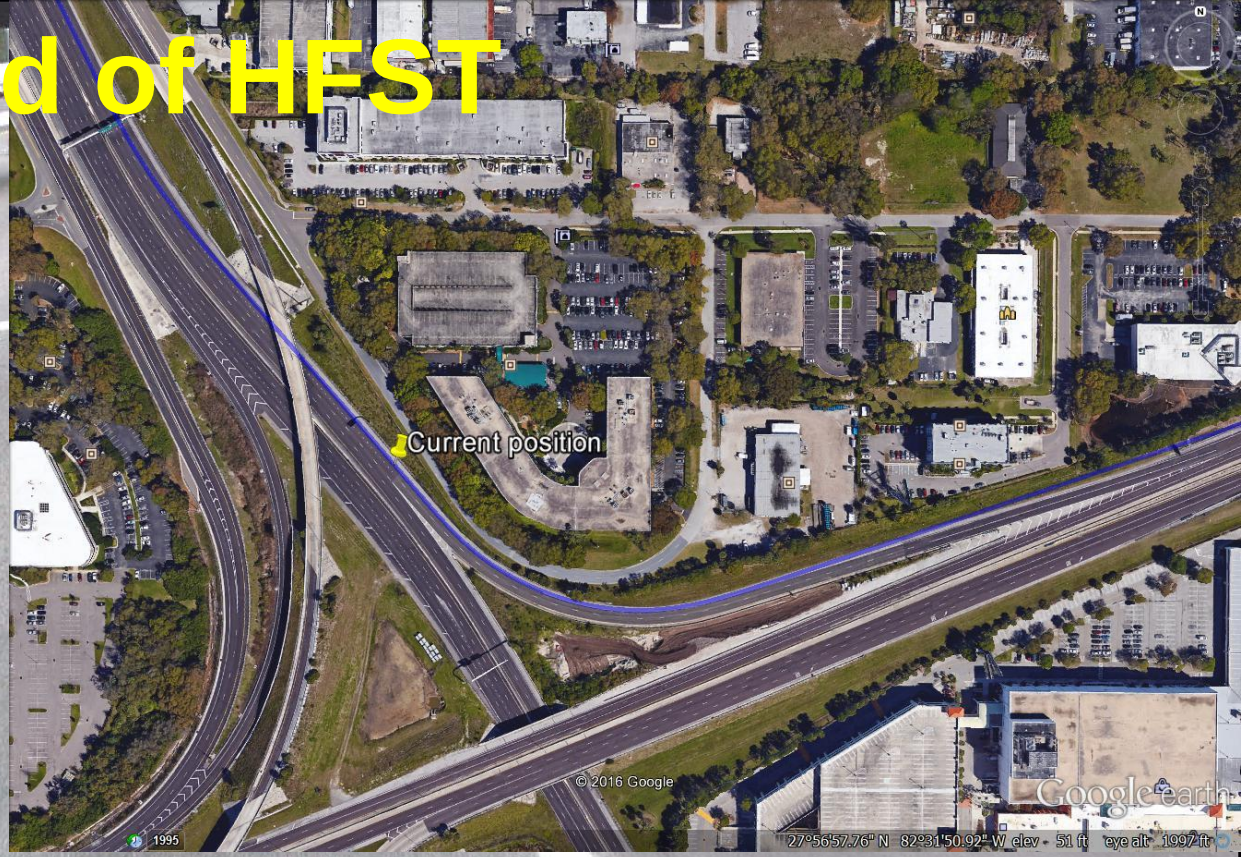
CASE 4

- Interstate I-275 Tampa, Florida
- To TOLL 589
- HFST
- Friction and Texture

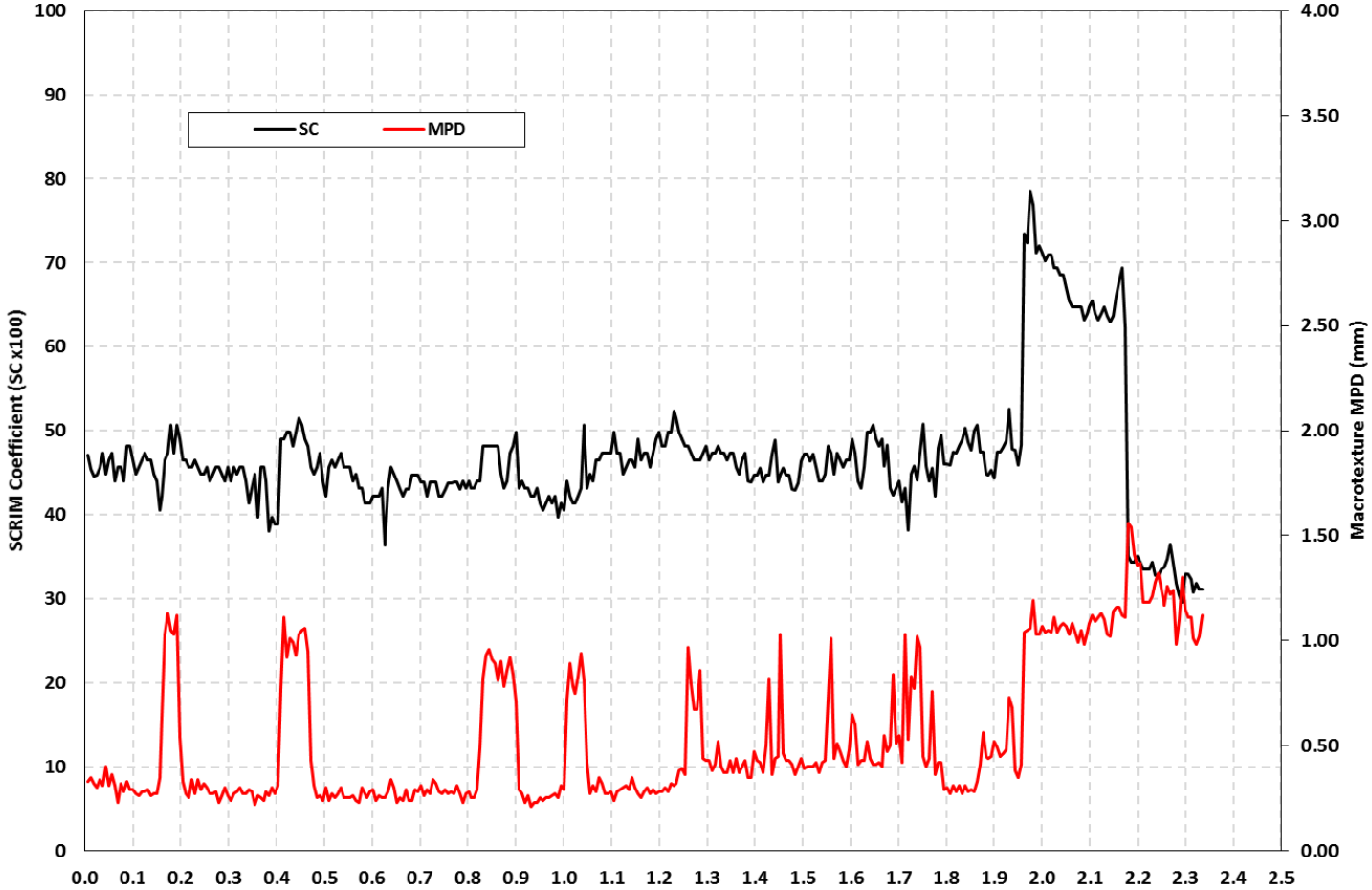

Case 4
Start
End
Current position
Beach Park
Swann Estates
Bon Air
Gray
© 2016 Google
Google earth
1995
27°57'08.48" N 82°30'55.98" W elev 28 ft eye alt 9197 ft


Start of HFST
35
MPH
Current position
© 2016 Google
Google earth
1995
27°56'55.88" N 82°31'51.62" W elev. 16 ft eye alt 2144 ft

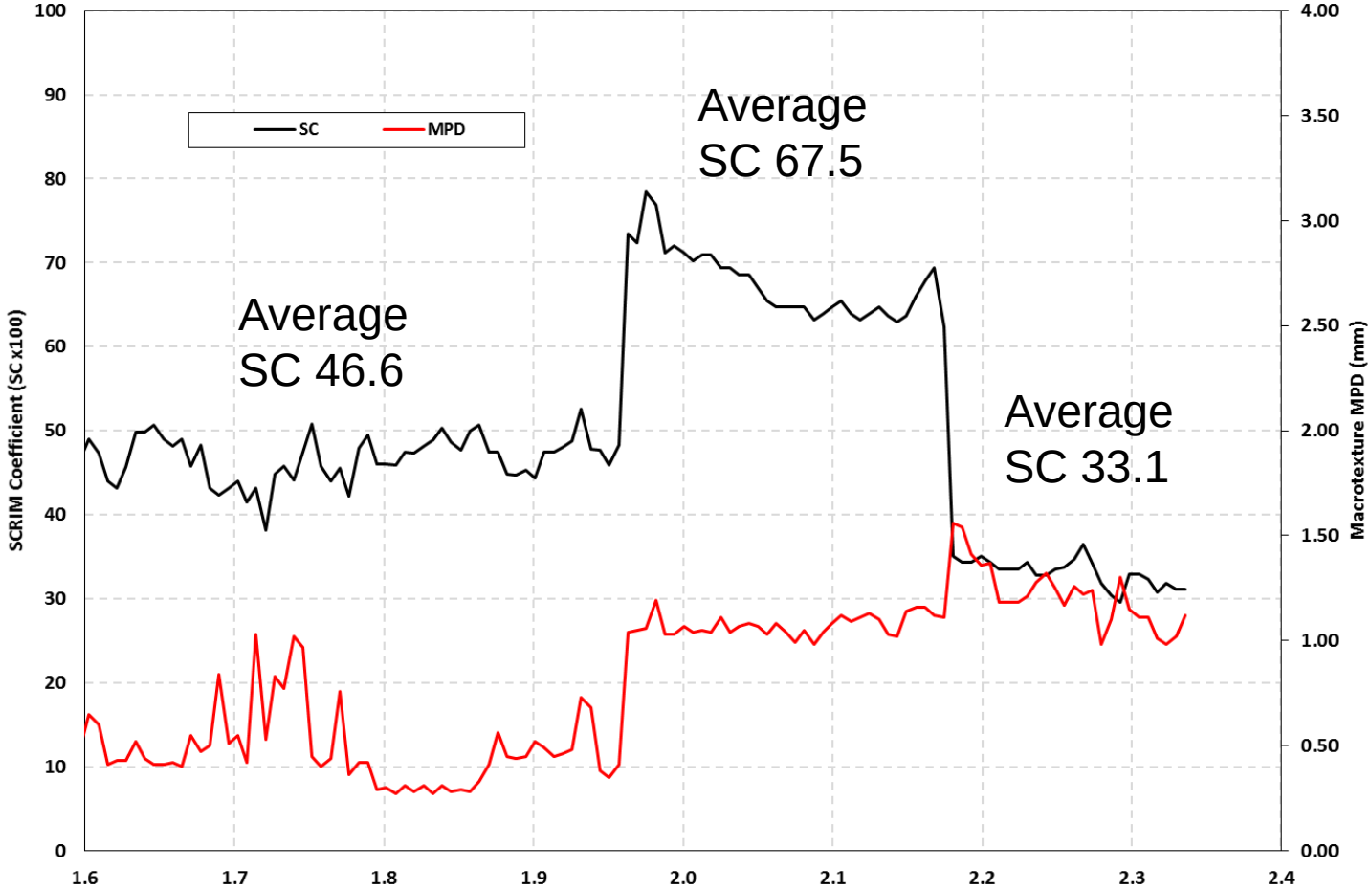
End of HFST


Current position
© 2016 Google
Google earth
1995
27°56'57.76" N 82°31'50.92" W elev - 51 ft eye alt 1097 ft

Exit 39 from I-275 to Memorial Highway (Toll 589)



Exit 39 from I-275 to Memorial Highway (Toll 589)




Ramp entrance


Ground sections

Final Considerations

- 49/50 States use the locked-wheel
- Limitations: Curves, ramps, and cannot do continuous (every 0.3, 0.5, 1.0 miles, +)
- Macrotexture possible, not common
- Crash data analysis needs friction data
- http://vtrc.virginiadot.org/PubDetails.aspx?PubNo=16-R8

Final Considerations

- Water ± 2 gal @40 mph, so every 0.1 mile:
- 300 gallon tank, 150 tests, 15 miles
- 1000 gallon tank, 500 tests, 50 miles

Summary:	E-274	SCRIM
Miles/day:	50	300
Miles/Year:	6,000	36,000
Direct Cost/mile	$15.82	$8.72

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Transportation Institute

ppc16

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- WASH DOT: David Luhr and Jianhua Li
- TTI: Don Zimmer and Dusty Arrington

Questions?


690 FB


Friction Testing
This Vehicle Leaves Water Trails
690 FB

Questions?

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