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CRASH ELASTICITY OF SPEED-ADJUSTED PAVEMENT FRICTION ACROSS ROADWAY FACILITY TYPES

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INTRODUCTION

Why should we care about pavement friction?

INTRODUCTION

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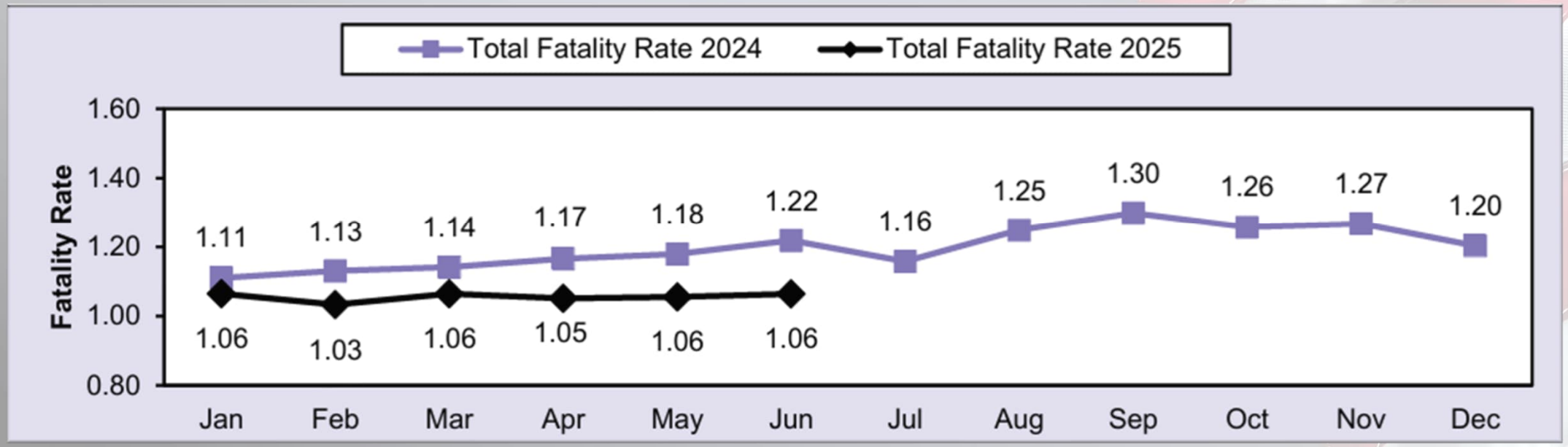
- 2025 Trend: The National Safety Council (NSC) reported at approx. 37,810 in traffic deaths in 2025, indicating continued challenges in roadway safety.

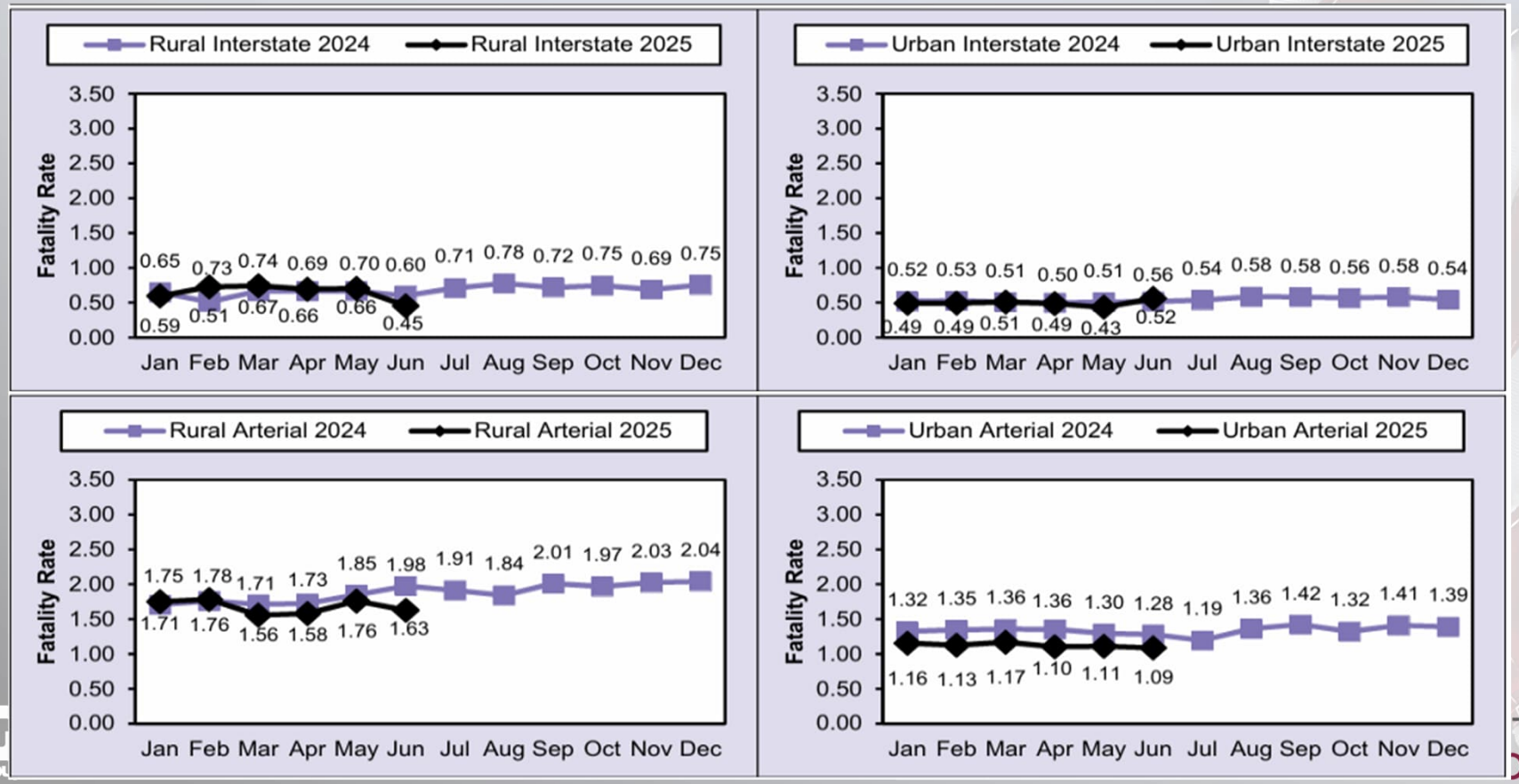
- 2026 Projections: Early forecasts for January-March 2026 anticipated 5,980 total traffic deaths.

NHTSA 2025



INTRODUCTION (CONT.)

- FATALITY RATE IN RURAL AREAS REMAINS 2.4 TIMES HIGHER THAN THAT IN URBAN ROADS, DEMONSTRATING THE SIGNIFICANT DIFFERENCE IN ASSESSING SAFETY BETWEEN ROADWAYS AND SITE TYPES. *NHTSA, 2021*
- SAFETY IMPROVEMENTS MUST ADDRESS ALL ROADWAY FUNCTIONAL CLASSIFICATIONS.



INTRODUCTION (CONT.)

Traveling Speed

Road Geometry

Traffic Exposure

Pavement Surface properties

Roadway Classification

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OBJECTIVES

- Support reducing roadway crashes and improve safety through:
  - Develop a unified friction–macrotexture safety index
  - Assess feasibility of a new pavement safety metric that integrates friction and macrotexture across different roadway types
  - Enable network-level friction management using the proposed combined performance indicator

MERIT

This study aligns closely with the Safe System Approach, addressing a critical aspect of highway safety by integrating pavement surface characteristics into safety modeling.

- Propose a Novel Approach:
  - Proposes a novel approach to estimate the available friction at the facility operating speed
  - Index captures speed-dependent interaction of friction & macrotexture

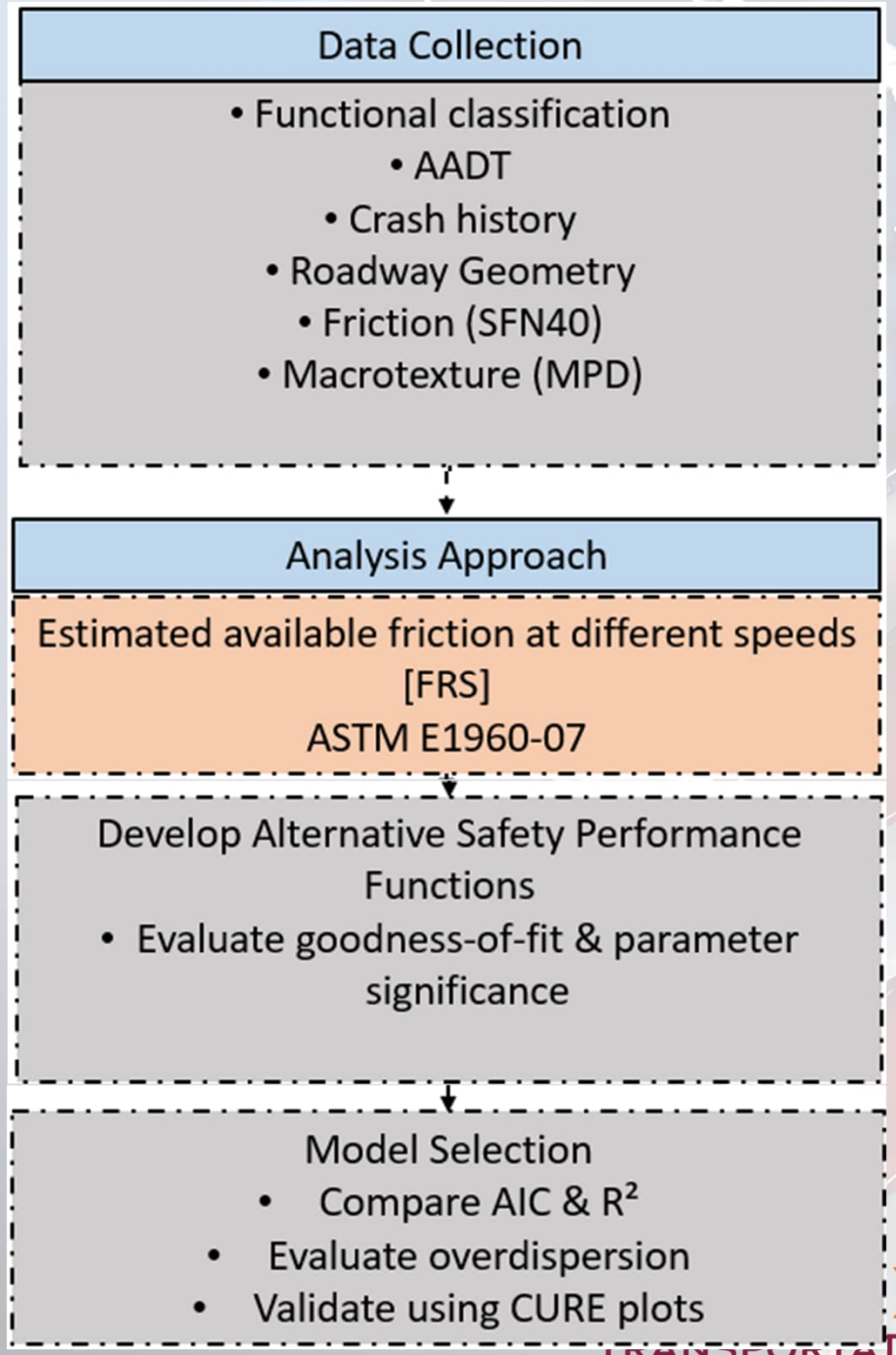
METHODOLOGY

Framework

For Speed-Dependent SPF Development:

1. Analysis framework overview

Speed-dependent friction-based SPF development

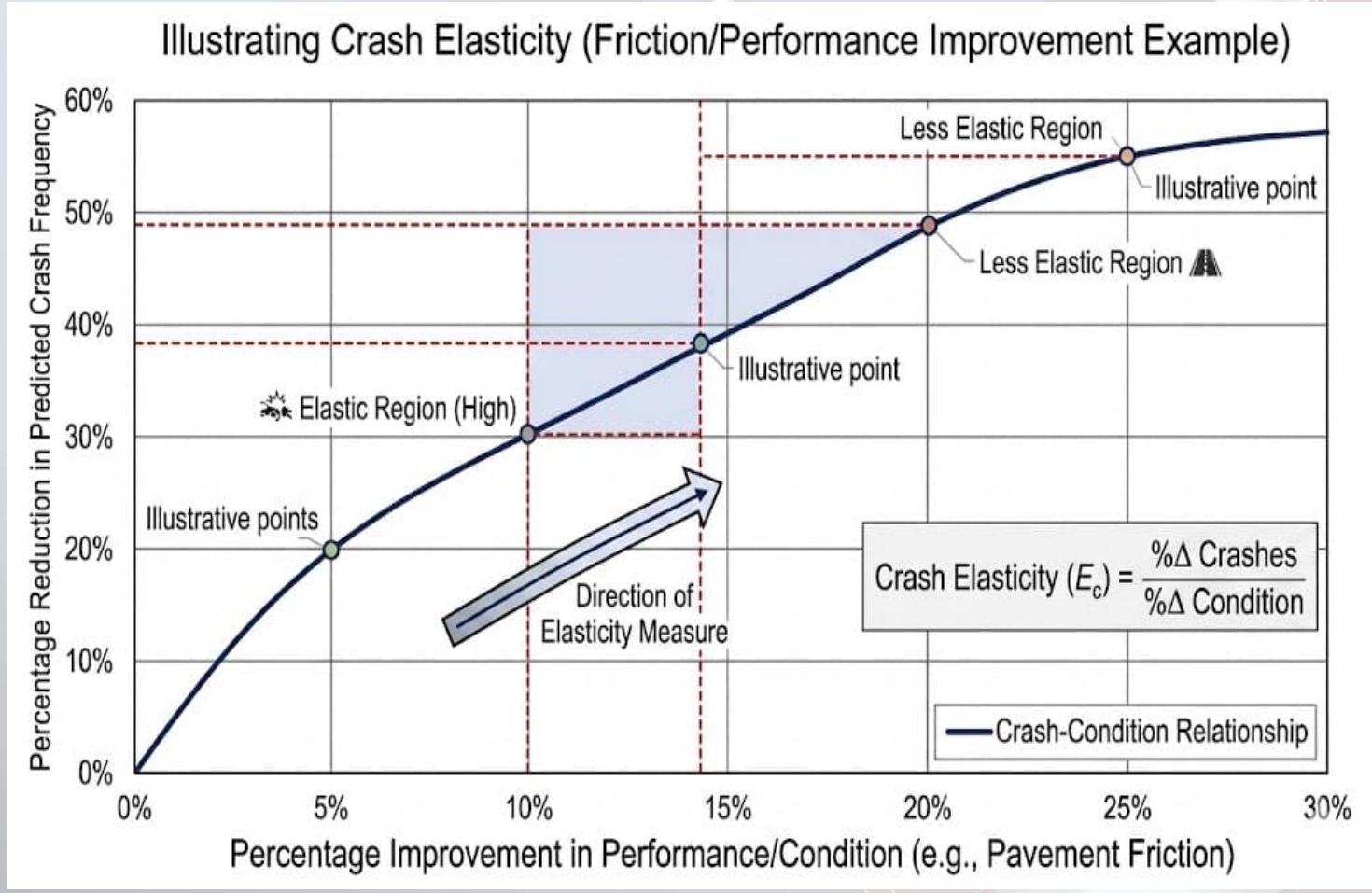


METHODOLOGY

FRAMEWORK (CONT.)

WHAT IS CRASH ELASTICITY:

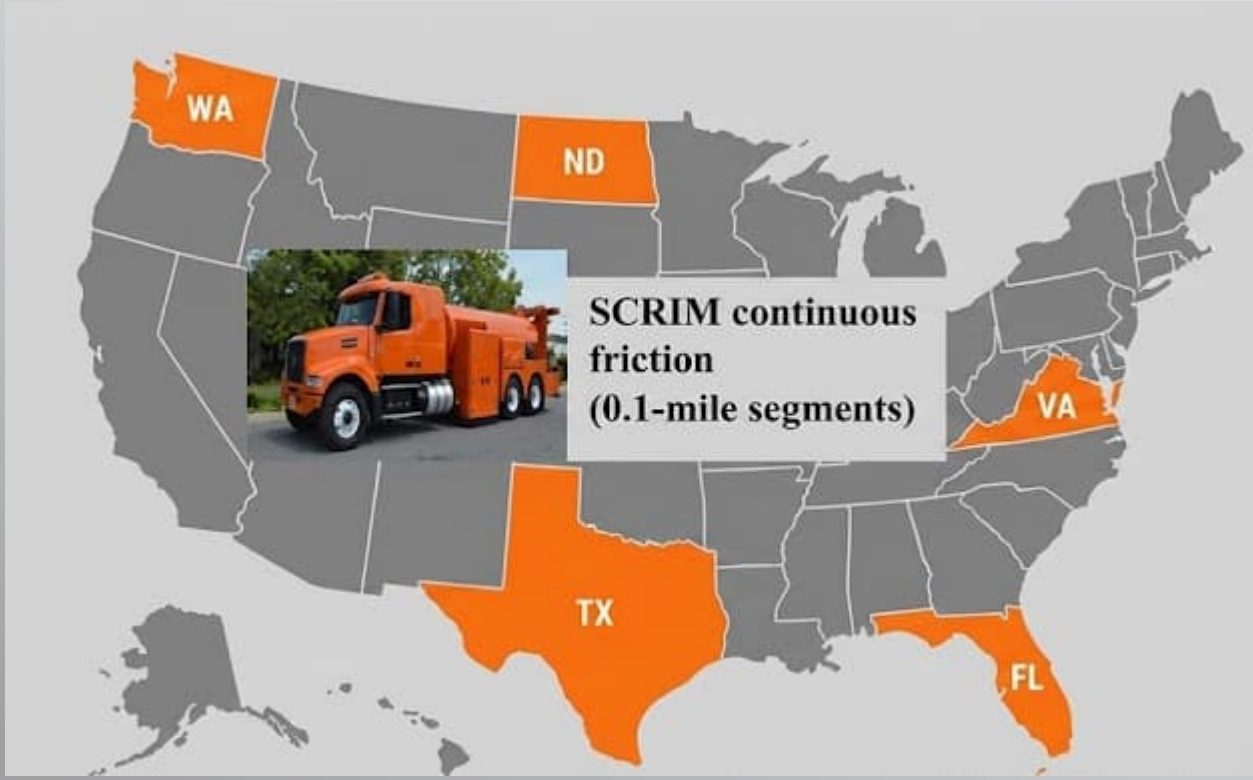
MEASURES HOW MUCH CRASHES CHANGE WHEN FRICTION IMPROVES



LOCATION

Total Network Analyzed: ~7,000 miles

Validation Dataset: 5 States | > 300,000 Crashes



Freeways: 2,447 miles

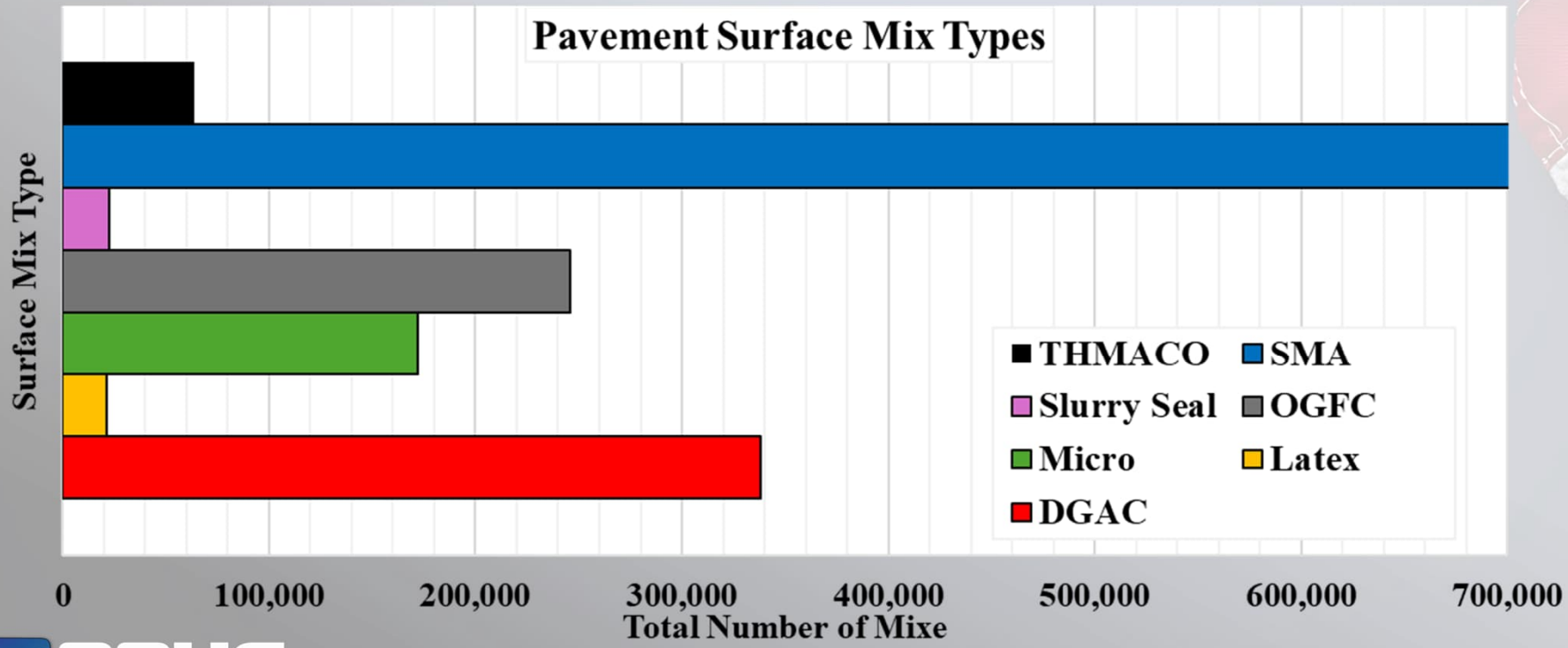
Rural Highways: 2,468 miles

Arterial: 2,076 miles

DATA OVERVIEW

Data for SPF development:

Distribution of pavement surface mix types included in the SPF analysis



Pavement & Geometric Variables
Sideway-force Friction [SCRIM (SFN(40))]
Macrotexture [Mean Profile Depth (MPD, mm)]

- ❑ Vertical Grade (%)
- ❑ Cross-slope (%)
- ❑ Horizontal Curvature (1/m)

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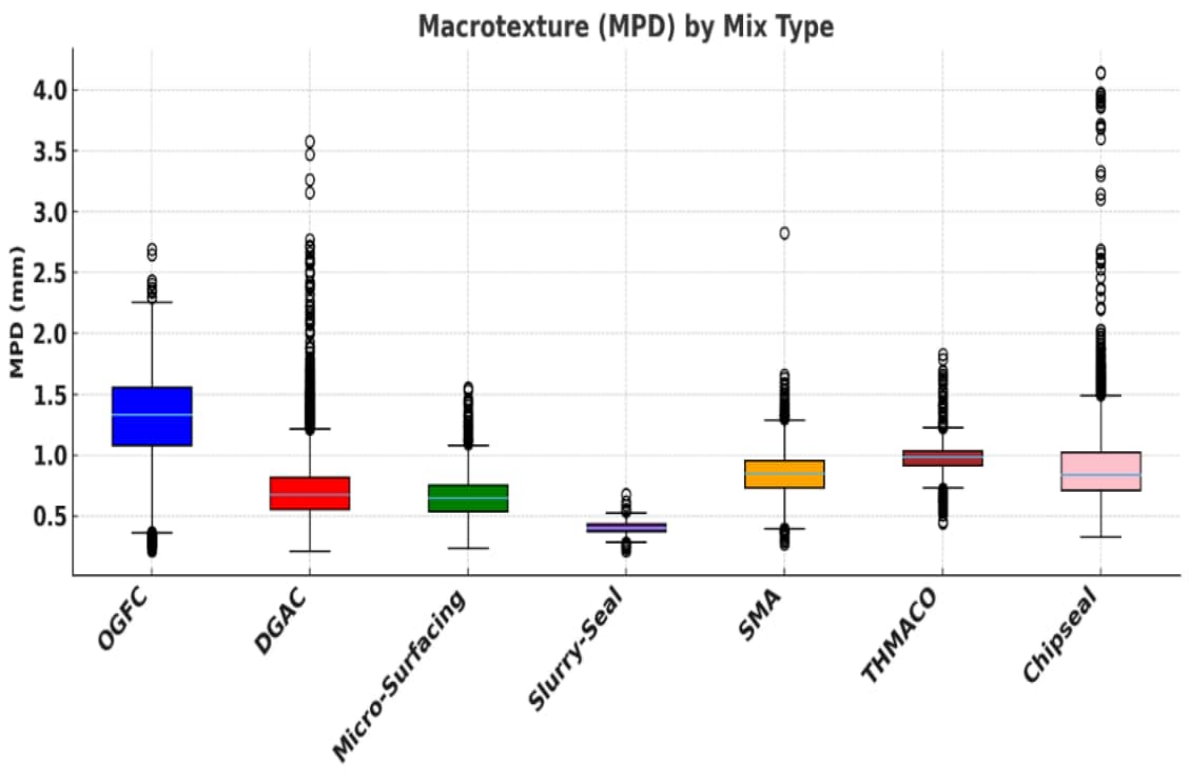
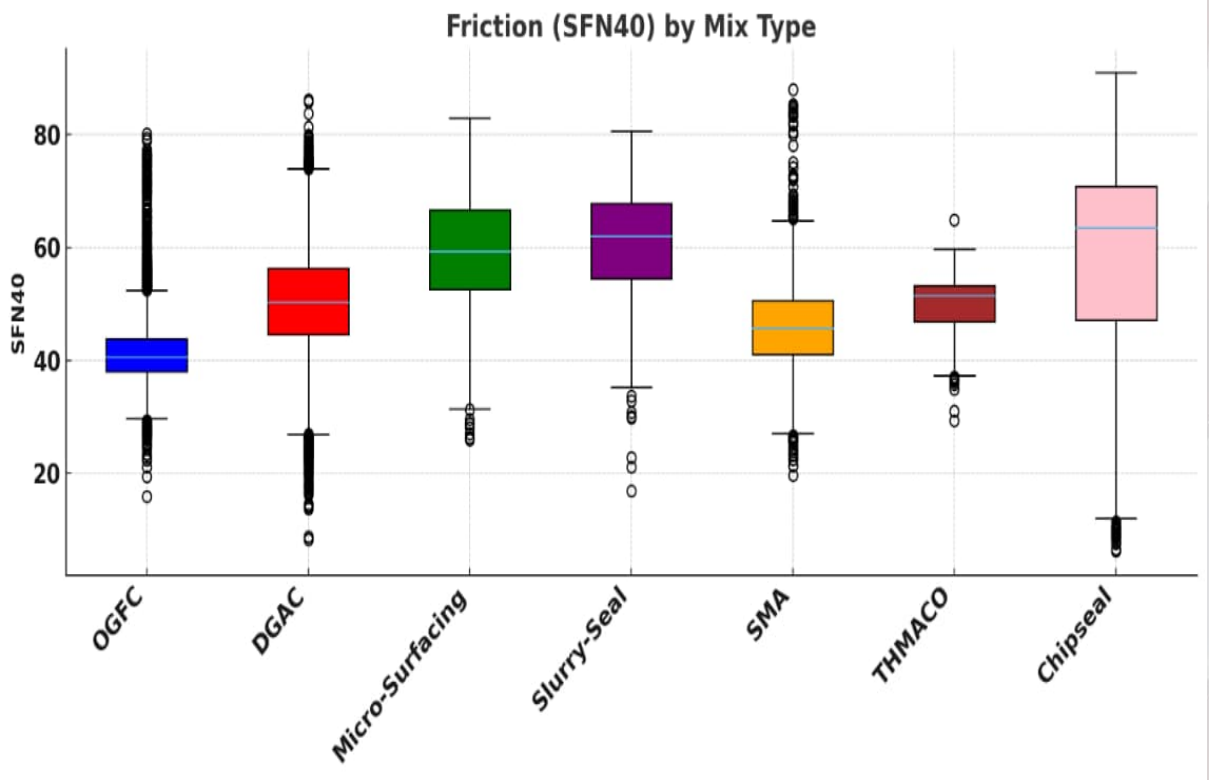
SURFACE CHARACTERISTICS BY MIX TYPE

Key Insights

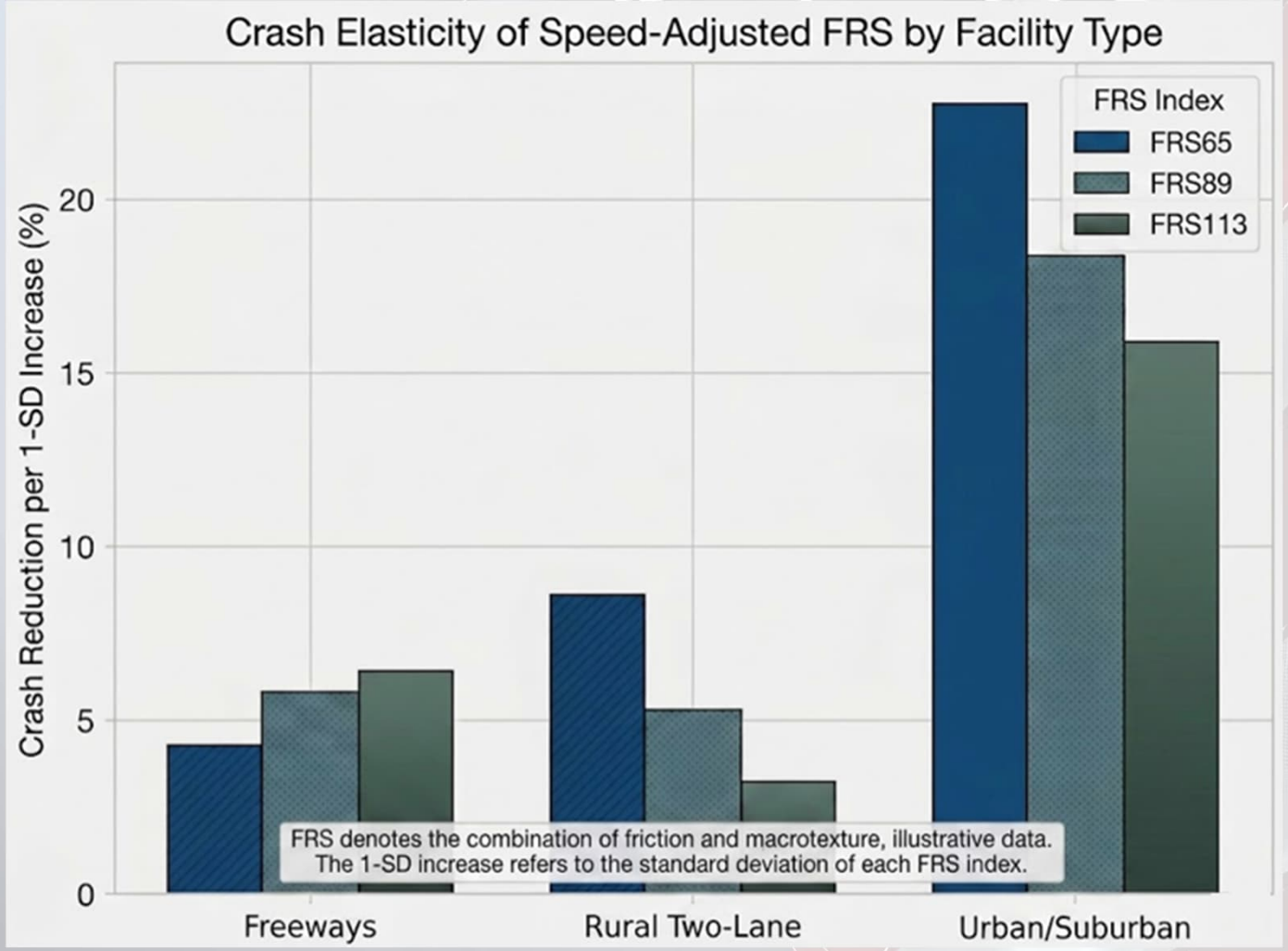
- Mix types exhibit distinct friction & macrotexture
- No single metric fully captures safety performance
- Joint consideration of MPD and friction is required





RESULTS (CONT.)

- Pavement Condition Sensitivity
- Optimal Investment Allocation
- Model Instability Explained: The



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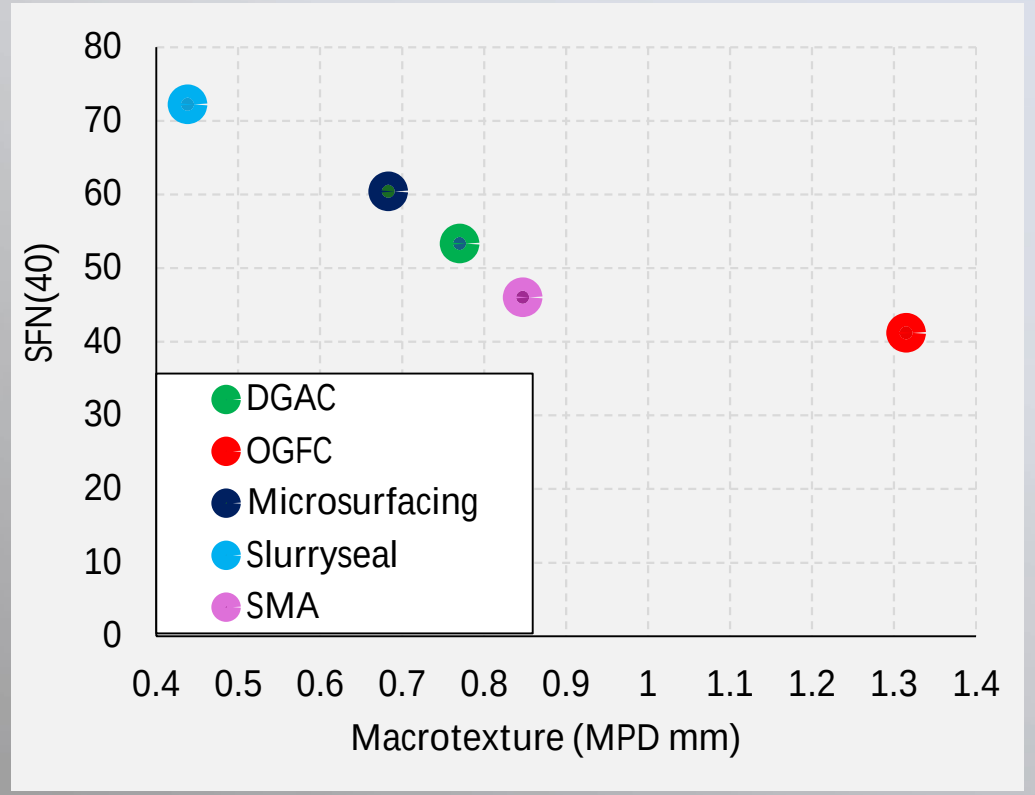
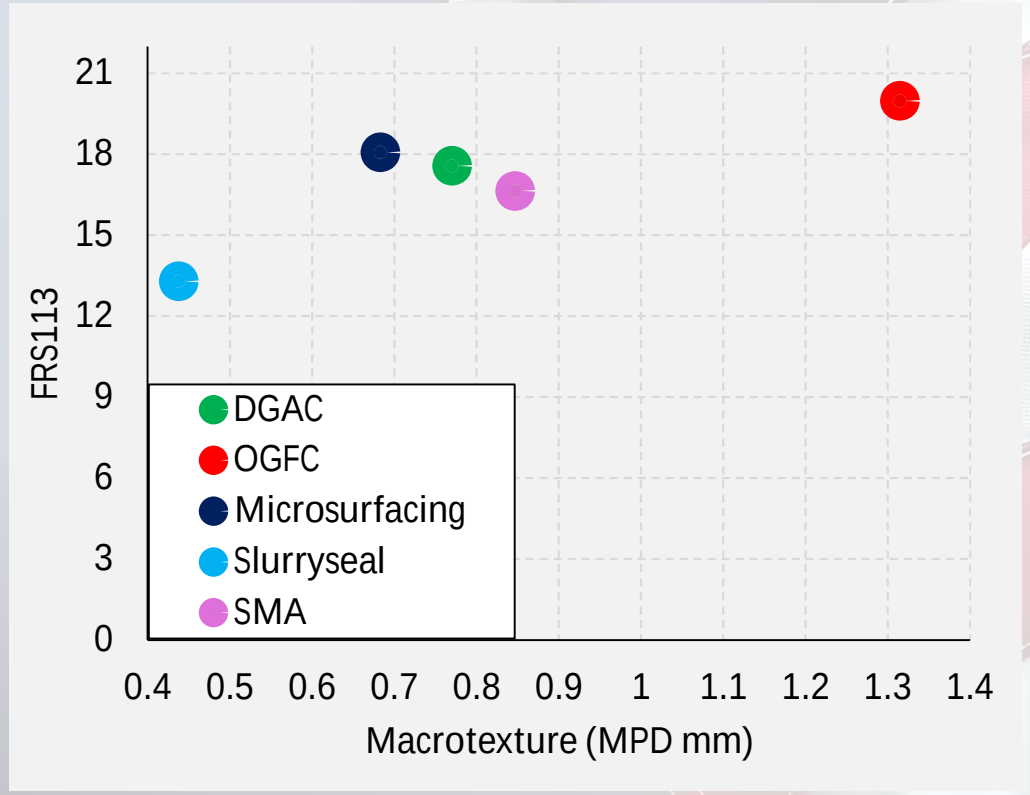
MODEL EVALUATION

- SFN(40) HAS LIMITED SENSITIVITY TO MACROTEXTURE
- MACROTEXTURE PLAYS A STRONGER ROLE AT HIGHER OPERATING SPEEDS





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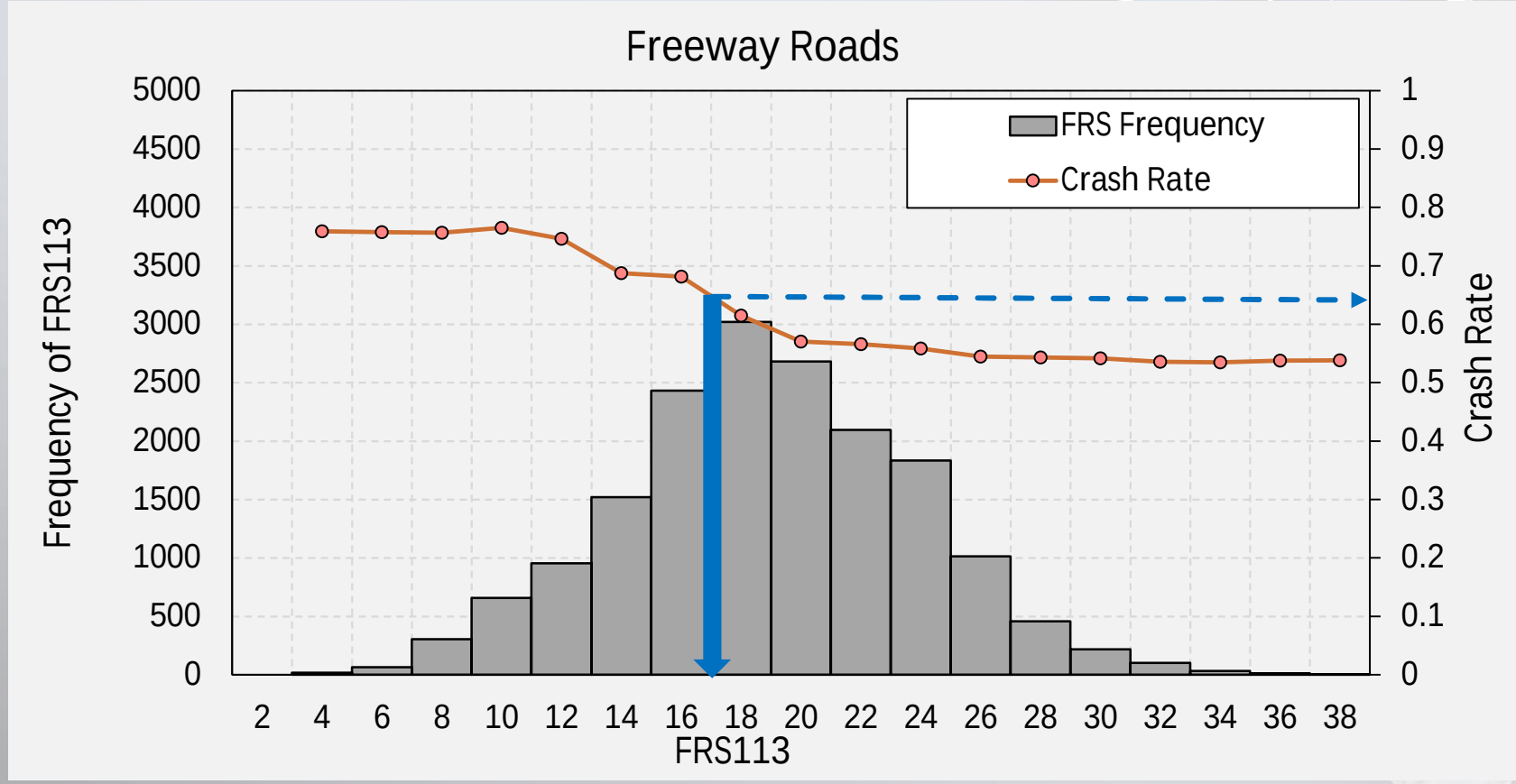
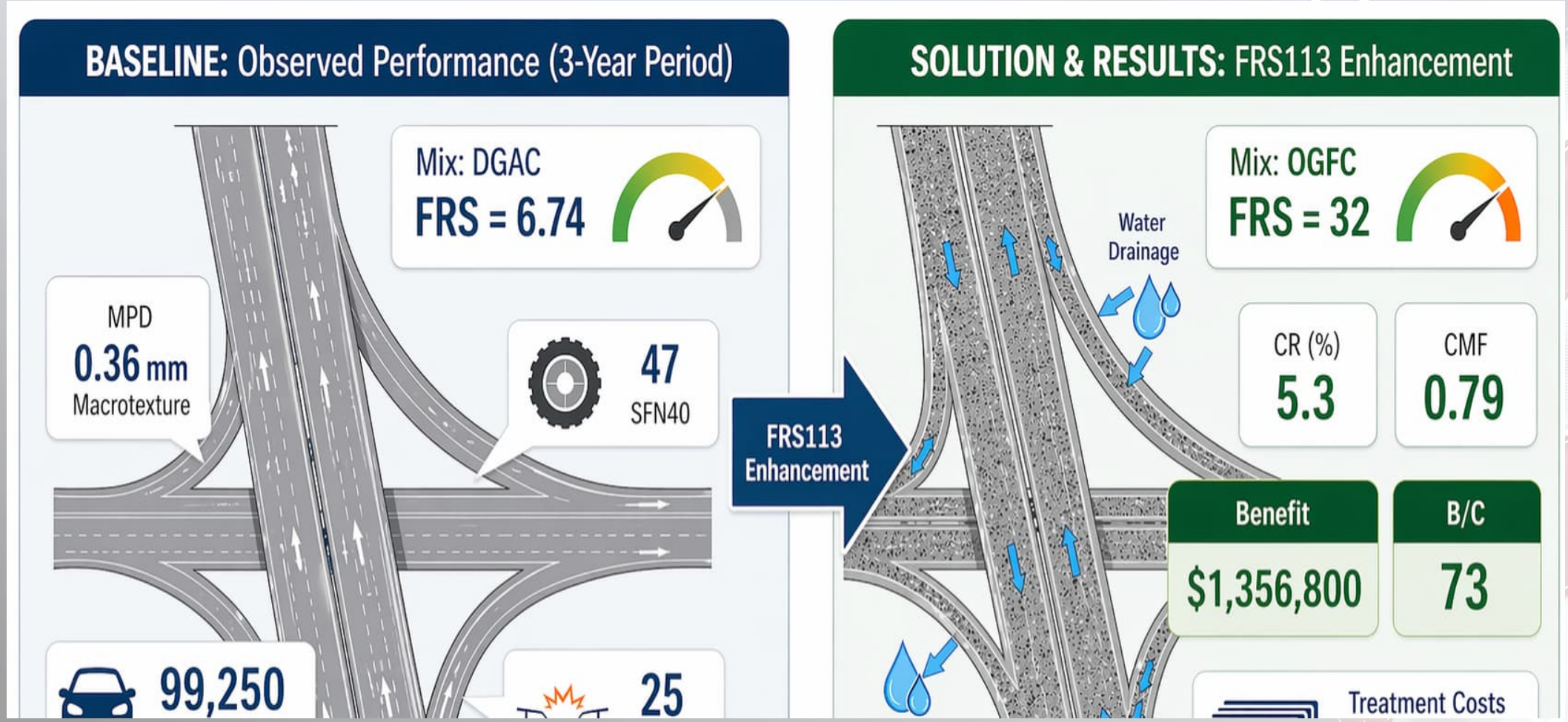
INVESTIGATORY LEVEL



- ILLUSTRATIVE EXAMPLE OF INVESTIGATORY THRESHOLD ESTIMATION FOR FREEWAYS.

BENEFIT-COST ANALYSIS

- SAFETY AND ECONOMIC IMPACT OF FRS113 IMPROVEMENTS ON FREEWAYS



FINDINGS

- Introduces a Novel Framework:
- As an estimation of available friction,

- Enables:
  - Estimation of safety benefits (CMF)
  - Evaluate the effectiveness of friction improvement treatments (B-C analysis)
  - Help defining high risk, friction-deficient segments (IL values)

CONCLUSIONS

- THE WORK OF THIS DISSERTATION SUPPORTS REDUCING CRASHES:

- A UNIFIED SAFETY METRIC CAPTURES THE COMBINED EFFECTS OF FRICTION AND MACROTEXTURE ACROSS DIFFERENT ROADWAY TYPES AND OPERATING SPEEDS:

FRS113 → FREEWAYS

FRS65 → RURAL TWO-LANE, TWO-WAY HIGHWAYS

SFN40 & MPD → URBAN & SUBURBAN ARTERIALS

FUTURE WORK

- Incorporate segment-level speed data (posted or operating speeds)
  → Improve accuracy of friction adjustment

- Conduct before–after (treatment-based) studies
  → Understand causal impact of friction improvements on crashes

- Expand datasets to include:

Wider range of Traffic volumes (AADT)

Speed limits

Broader geographic regions

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THANK YOU

QUESTIONS ?

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