# Delivering and Managing Roads for Safety Using Continuous Friction Measurement

Ryland Potter
Director of Business Development, WDM USA

Presentation prepared for the *Asset Management and Road Safety* session of the 2020 TAC Conference & Exhibition, Vancouver, B.C.

# OVERVIEW

- What is the relationship between friction and safety?

- How can we improve road safety through technical road maintenance and safety-focused asset management?

- What are lessons learned for sustaining pavement friction management program benefits while adapting to changing budgetary and industry conditions?

# MANAGING FRICTION: A SAFETY PERSPECTIVE

- "The four major reasons roadway departures occur are roadway conditions, collision avoidance, vehicle failure, and driver error. At least three of these may be impacted by safety improvements within the road surface that can increase the coefficient of friction." – TRB

- "Increasing skid resistance on rural roads reduces crashes resulting in fatalities and/or serious injuries by 30%." – USDOT

- "Research conducted by the NTSB and FHWA indicates that about 70% of wet pavement crashes can be prevented or minimized by improved pavement friction. – FHWA

- Increasing side-force friction coefficient by 0.1 (SFC of 10) reduces crash rates on average by 30% on wet roads and 20% on dry roads and has been shown to reduce skid-related fatalities by up to 40%. – NZTA

# MANAGING FRICTION: AN ASSET MANAGEMENT PERSPECTIVE

Pavement friction management's purpose is to minimize friction-related vehicle crashes by:

1) Ensuring pavement surfaces are designed, constructed, and maintained to provide adequate and durable friction properties,

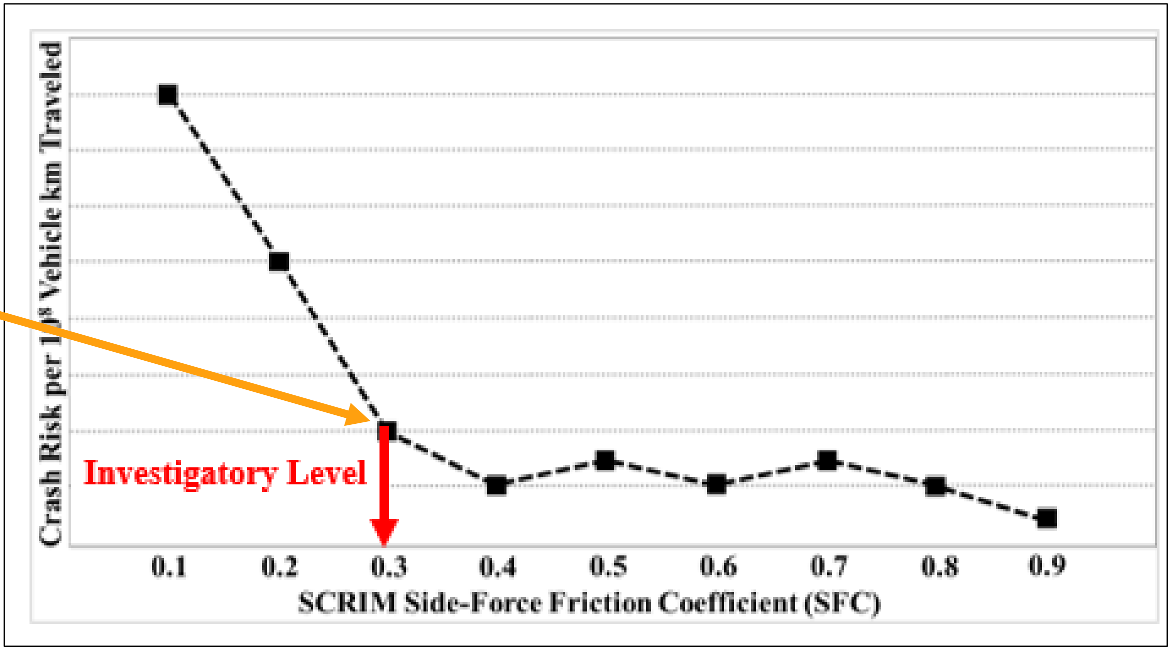
2) Identifying and correcting sections of roadways that have elevated friction-related crash rates, and

3) Prioritizing resources to reduce friction-related vehicle crashes in a cost-effective manner.

# HOW MUCH FRICTION IS ENOUGH?

- Managing friction relies on a system of identifying appropriate/adequate skid resistance levels for various locations, “in proportion to the ‘crash risk’ presented at those locations”

- Most transportation authorities set levels by plotting crash risk against network-level friction measurements to find the inflection point where crash risk increases rapidly with lower friction




- Some evidence that investigatory levels are broadly similar across different networks **BUT** there is no set methodology to determine a skid resistance threshold that will make a hazardous location ‘safe’

# EFFECTIVE PAVEMENT FRICTION MANAGEMENT RELIES ON CONTINUOUS FRICTION MEASUREMENT

**Two "knowns" of friction:**

1) Friction's ability to reduce crashes is greatest at high-risk areas, e.g., curves, intersections, congestion zones, work zones, ramps and highway merges, and grade changes.

2) Friction supply is often lowest where friction demand is highest and is highly variable: cross-slope, pavement design life, aggregate selection, traffic volumes, and texture play a role

**Continuous friction facilitates**:

1) Measurement through curves, ramps, highway merges, grade changes, and at intersections

2) Greater precision and detail of spatial variability – data for every foot of every mile vs. sample

3) Greater correspondence to current vehicle operating conditions (testing in the same critical slip range as ABS-equipped vehicles)

4) The creation of a common measure/shared dataset from which multiple divisions can make decisions

# CONTINUOUS FRICTION USE CASES

1) **Monitoring network skid resistance using formal pavement friction management program**
2) Inventorying horizontal curves, modeling approach and curve speeds, and predicting curve crash risk and severity
3) Delineating impact of friction, texture, geometrics, etc. on safety performance
4) Improving countermeasure selection and countermeasure placement
5) Refining aggregate selection in design and maintenance
6) Building better asset deterioration and lifecycle cost models

# EVOLUTION OF PAVEMENT FRICTION MANAGEMENT

**1958** — **1[st] Int'l Conference on Skid Resistant Pavement**

## United Kingdom

**1973** — LR510: A Guide to Skidding Resistance for Roads

**1976** — 1[st] specs for aggregate properties and texture depth (H1/6/76)

**1987** — Policies on skid resistance & aggregate properties (HD 15/87 & HA 36/87)

**2006** — Review/updates to skid policy and aggregate standards (LR510 (73), HD28/94, HD28/04, HD36/06)

**2019** — UK CS 228: "The provision of appropriate levels of skid resistance is treated primarily as an asset management issue rather than one of road safety engineering"

## United States

**1976** — AASHTO Guidelines for Skid Resistant Pavement Design

**1980** — *NTSB concludes that fatal accidents occur on wet pavements 3.9-4.5x the rate on dry pavements*

**2004** — *State-level WARPs report results: wet accident rate 44% higher for sites with skid numbers <= 30 than for sites with skid numbers >30*

**2010** — FHWA Pavement Friction Mgmt Advisory (T5040.38)

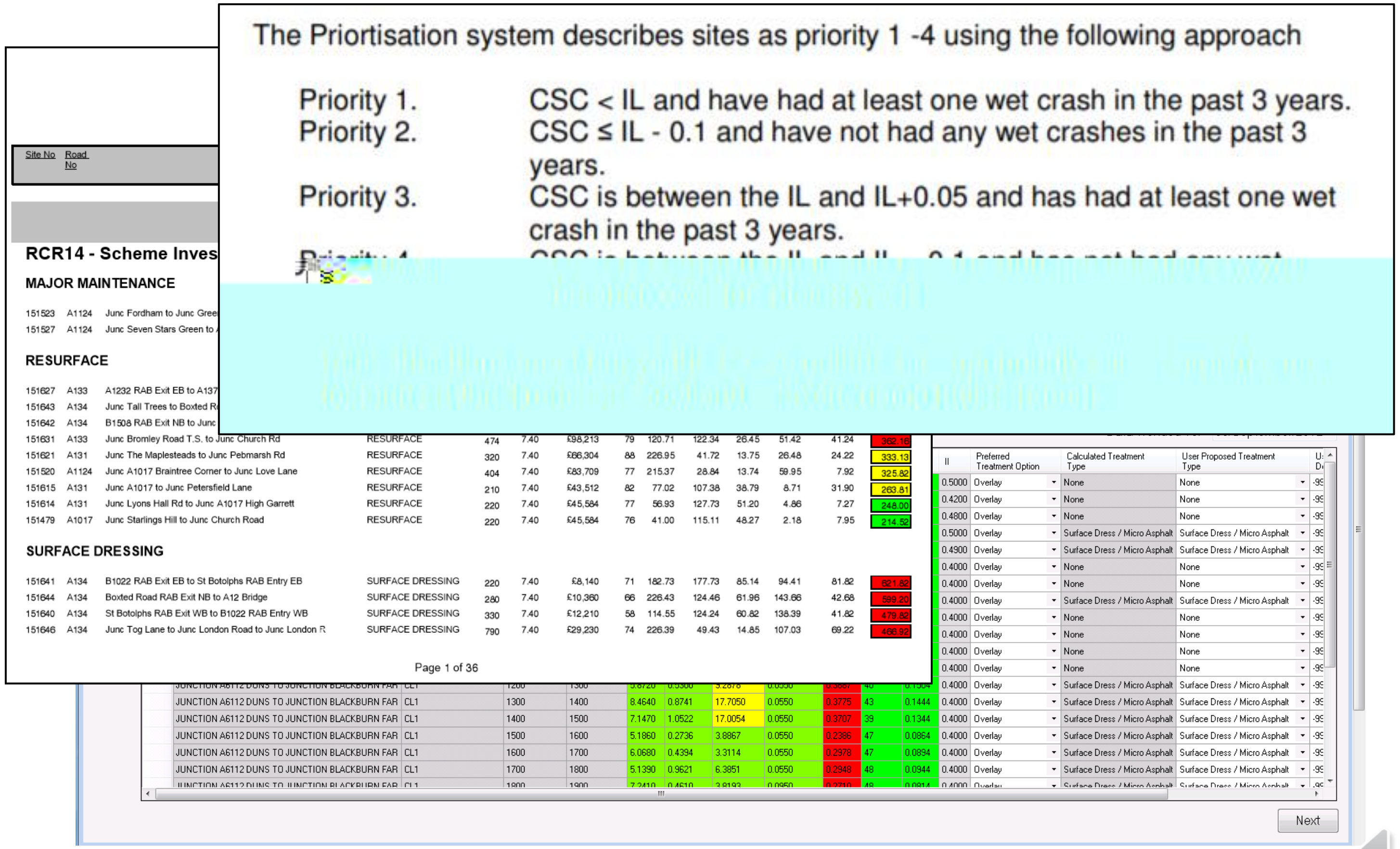
**2015** — FHWA pilots Pavement Friction Mgmt Programs in four states

**2020** — FHWA announces effort to "advance continuous pavement friction measurement techniques and practices for improving safety in the US"; network-level, continuous friction-based pavement friction management program development and/or testing in additional six states

# CASE STUDY: TRANSPORT SCOTLAND

- Overarching objective to “maintain a consistent approach to provide a level of skid resistance appropriate to the nature of the road environment” – differs from the UK in the specifics of its prioritization framework

- Prioritization is a two-stage process, where
  - (1) treatment sites are ranked and added to the structural maintenance program and,
  - (2) structural maintenance schemes are reviewed and ranked by a compound factor of safety (wet crash reduction a particular target), journey time reliability, environmental sustainability, and value for money




- Model maintenance needs and discounted/undiscounted program costs as far as 40 years in the future

# CASE STUDY: NEW ZEALAND TRANSPORT AGENCY

- Pavement friction management program evolved from hotspot reduction to a proactive "safety management" approach with an overarching objective of "equalizing crash risk while maintaining an economic balance"

- Projects scored using a "best value safety outcome" metric – sites are prioritized based on the difference between friction demand and supply and observed crashes and treatment costs are analyzed using BCR and calculating a "safety savings" NPV

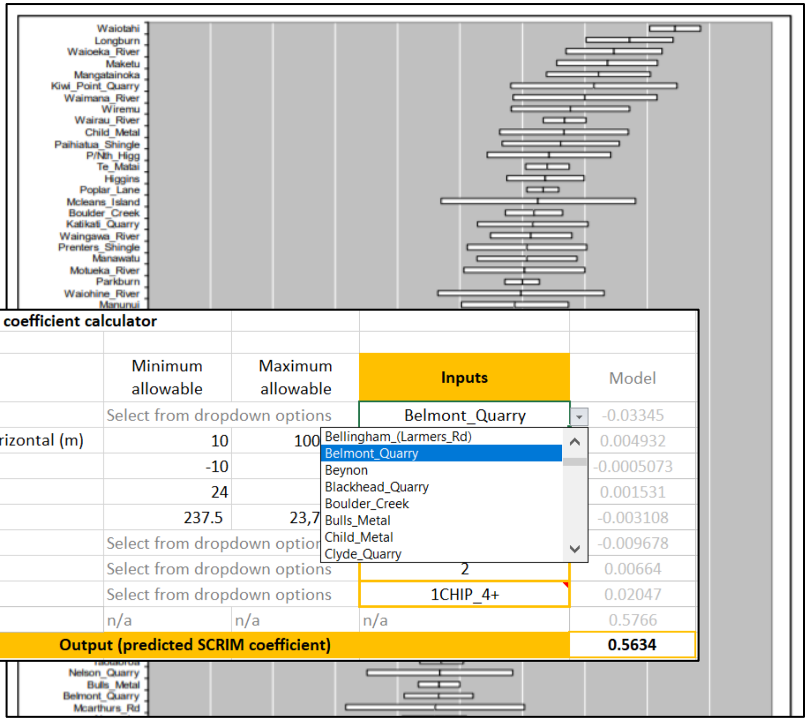
- Treatments are selected if they achieve a BCR >20 or meet a metric of # fatalities and serious injuries saved over 10 years per $100 million invested

- To avoid potential conflicts between asset preservation and safety when budgets are constrained, NZTA has "ring-fenced" funding to address sites where skid resistance and safety are the only treatment drivers; NZTA also tracks the amount of duplicate surfacing activity eliminated with timely maintenance treatments that are selected to achieve a safety outcome

# COMPARATIVE EXAMPLE: HFST SPECIFICATION

| Site description | IL | PSV required for given IL, traffic level and type of site | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Traffic (cv/lane/day) at design life | | | | | | | | | |
| | | 0-250 | 251-500 | 501-750 | 751-1000 | 1001-2000 | 2001-3000 | 3001-4000 | 4001-5000 | 5001-6000 | Over 6000 |
| Motorway | 0.3 | 50 | 50 | 50 | 50 | 50 | 55 | 55 | 60 | 65 | 65 |
| | **0.35** | **50** | **50** | **50** | **50** | **50** | **60** | **60** | **60** | **65** | **65** |
| Non-event carriageway with one-way traffic | 0.3 | 50 | 50 | 50 | 50 | 50 | 55 | 55 | 60 | 65 | 65 |
| | **0.35** | **50** | **50** | **50** | **50** | **50** | **60** | **60** | **60** | **65** | **65** |
| | 0.4 | 50 | 50 | 50 | 55 | 60 | 65 | 65 | 65 | 65 | 68+ |
| Non-event carriageway with two-way traffic | 0.35 | 50 | 50 | 50 | 55 | 55 | 60 | 60 | 65 | 65 | 65 |
| | **0.4** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** | **68+** |
| | 0.45 | 60 | 60 | 65 | 65 | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ |
| Approaches to and across minor and major junctions, approaches to roundabouts and traffic signals | **0.45** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** | **68+** | **68+** | **HFS** |
| | 0.5 | 65 | 65 | 65 | 68+ | 68+ | 68+ | HFS | HFS | HFS | HFS |
| | 0.55 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| Approaches to pedestrian crossings and other high-risk situations | **0.5** | **65** | **65** | **65** | **68+** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** |
| | 0.55 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| Roundabout | **0.45** | **50** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** |
| | 0.5 | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ |
| Gradient 5-10% longer than 50m | **0.45** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** | **68+** |
| | 0.5 | 60 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| Gradient >10% longer than 50m | 0.45 | 55 | 60 | 60 | 65 | 65 | 68+ | 68+ | 68+ | 68+ | 68+ |
| | **0.5** | **60** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** |
| | 0.55 | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| Bends radius <500m - carriageway with one-way traffic | **0.45** | **50** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **HFS** | **HFS** |
| | 0.5 | 68+ | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| Bend radius <500m - carriageway with two-way traffic | 0.45 | 50 | 55 | 60 | 60 | 65 | 65 | 68+ | 68+ | HFS | HFS |
| | **0.5** | **68+** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** |
| | 0.55 | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |

**UK policy recommends systemic HFST use based on friction demand and traffic**




**Aggregate model SCRIM coefficient calculator**

| | Minimum allowable | Maximum allowable | Inputs | Model |
|---|---|---|---|---|
| Pavement source | Select from dropdown options | | Belmont_Quarry | -0.03345 |
| Absolute curvature - horizontal (m) | 10 | 100 | | 0.004932 |
| Gradient (%) | -10 | | | -0.0005073 |
| Age (months) | 24 | | | 0.001531 |
| ADT (vehicles/day) | 237.5 | 23,7 | | -0.003108 |
| Skid-site category | Select from dropdown optior | | | -0.009678 |
| Surface function | Select from dropdown options | | 2 | 0.00664 |
| Surface category | Select from dropdown options | | 1CHIP_4+ | 0.02047 |
| Default | n/a | n/a | n/a | 0.5766 |
| **Output (predicted SCRIM coefficient)** | | | | **0.5634** |

Bellingham_(Larmers_Rd)
Belmont_Quarry
Beynon
Blackhead_Quarry
Boulder_Creek
Bulls_Metal
Child_Metal
Clyde_Quarry

**NZTA specifies naturally-occurring skid resistant aggregates, using modeling to predict/set skid performance targets for chipseals over a 10+ year service life**

# COMPARATIVE APPROACH: BALANCING SAFETY AND ASSET MANAGEMENT

**Transport Scotland**

+

- Predictable schedule/cost for investigations
- Easier to treat adjacent SCRIM sites as part of programmed maintenance/asset management

−

- Inconsistent standards triggering detailed investigation across network (different standards of use around crash records)
- Sites without history of crashes deprioritized

**NZTA**

+

- Ring-fenced funding removes “engineers’ dilemma between prioritizing asset preservation vs. safety when budgets are constrained”
- Ability to weigh proactively treating sites with low skid resistance but no recorded crash history

−

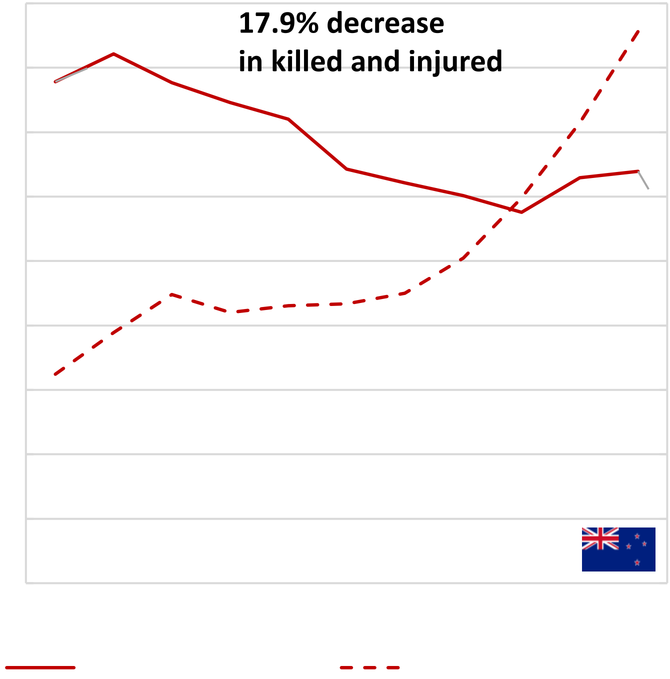
- Ring-fenced funding only covers surface-type treatments and some concern that cost a limiting factor if chipseal life is reduced
- Inconsistent application at local level

**Both offer flexibility to adjust based on different funding scenarios, promote systemically-effective skid treatments, and require a safety and asset management to be brought into balance.**

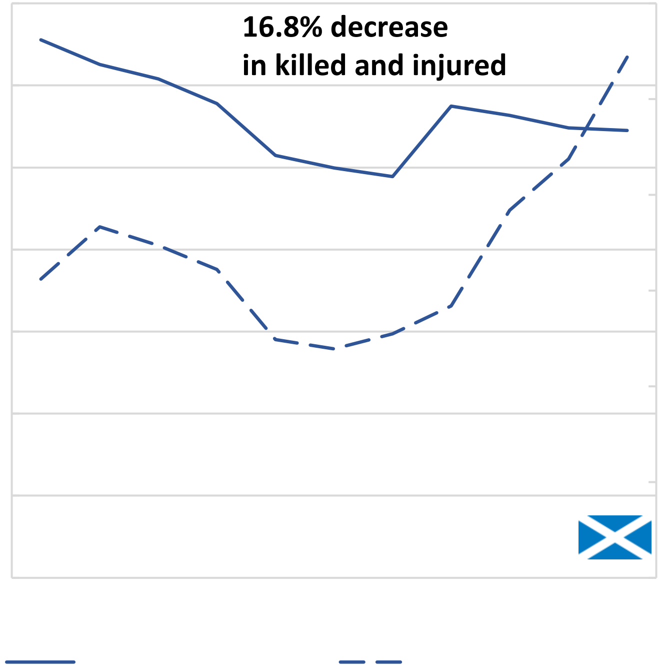
# TRANSPORT SCOTLAND AND NZTA OUTCOMES

*From 2006-2016, U.S. vehicle registrations increased 7.2% and vehicle miles travelled increased 5.3%. K&I increased from 2.6 million people to 3.2 million over the same period.*

**Traffic Volume vs. # of Accidents, New Zealand (2006-2016)**




**Traffic Volume vs. # of Accidents, Scotland (2006-2016)**




**Friction management program B/C between 13 and 36:1**

# CASE STUDY: "PAVEMENT FRICTION MANAGEMENT" (KENTUCKY TRANSPORTATION CABINET)

**Program Description: network-level collection of GPS-linked continuous friction and roadway geometric data to "make more informed decisions concerning the investment of highway funds"**

**Data Collection:**

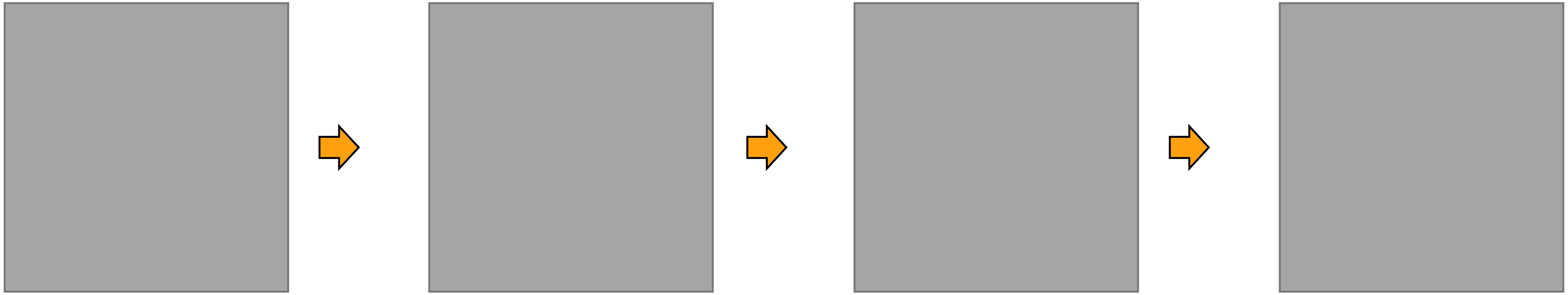
- 31,000 lane miles of state-maintained roads
- All interstate and parkway/highway (and associated ramps) on an annual basis, primary and secondary routes (and associated ramps) on a bi-annual basis

**Analysis/ Implementation:**

- Localized Investigatory Levels
- Localized Safety Performance Functions to inform BCA and countermeasure selection
- Site prioritization methodology review – choosing the optimal safety/asset management balance

# CASE STUDY: “SURFACE SAFETY ASSESSMENTS” (VIRGINIA DEPARTMENT OF TRANSPORTATION)

**Proposed process for using SCRIM continuous friction data for investigatory work:**



Three good case studies of district-level “surface safety assessments” from Virginia:

1) Treatment placement: where was precise start/end location of friction problem on a curve to better place HFST?
2) Treatment selection: which treatment along continuum to solve a hypothesized texture problem, but actually subtle cross-slope issue (slurry vs. HFST vs. realignment)
3) Treatment selection: which treatment along continuum to solve hypothesized friction problem, but actually a texture issue (microsurfacing vs. mill and replace)

# BEST PRACTICES IN PAVEMENT FRICTION MANAGEMENT PROGRAMS

**Data Collection:**

- Annual network surveys (including all facility types) using continuous friction
- Robust equipment calibration and traceable equipment certification process

**Analysis/ Implementation:**

- Creating localized standards and revisiting at set intervals
- Taking a proactive approach to corrective action
- Maintaining a balanced perspective on safety and asset management

**Management:**

- Integrating friction into AMS/PMS and design process
- Ring-fencing funding for friction-related maintenance
- Identifying an internal skid policy/program team

# HOW CAN DOTs/MOTs USE CONTINUOUS FRICTION?

- Recognize that everyone in the organization contributes to the essential and achievable goal of safer roads:
  - **What** = Safety
  - **When and where** = Maintenance
  - **How** = Materials
- Take a proactive approach to addressing skid resistance, where friction becomes another factor to manage (like rutting or cracking)
- Prioritize within the resources available
- Support asset management planning with better data and data quality management systems

Continuous friction links transportation authorities' service levels, infrastructure condition, and lifecycle management needs to enable better outcomes and greater value for money.

# Thanks!