Center for Sustainable and Resilient Infrastructure

TPF-5(345/463): Managing the Pavement Properties for Improved Safety

Final Report VTRC 22-R14 Pavement Friction Management Program Demonstration

Advancing Transportation Through Innovation

VIRGINIA TECH TRANSPORTATION INSTITUTE

Center for Sustainable and Resilient Infrastructure

Presentation Outline

- ✓ Objective
- ✓ Surveyed Network
- ✓ Analyzed Network
- ✓ Model Development and Economic Analysis
- ✓ Statewide Results
- ✓ Findings, Conclusions and Recommendations

http://vtrc.virginiadot.org/PubDetails.aspx?PubNo=22-R14

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Pavement Friction Management Program Pilot Demonstration

Objective:

To continue the development and implementation of a continuous data-based pavement friction management (PFM) program by exploring use of other important pavement characteristics and applying the program to a larger geographic region, referred to as the Corridors of Statewide Significance (COSS).

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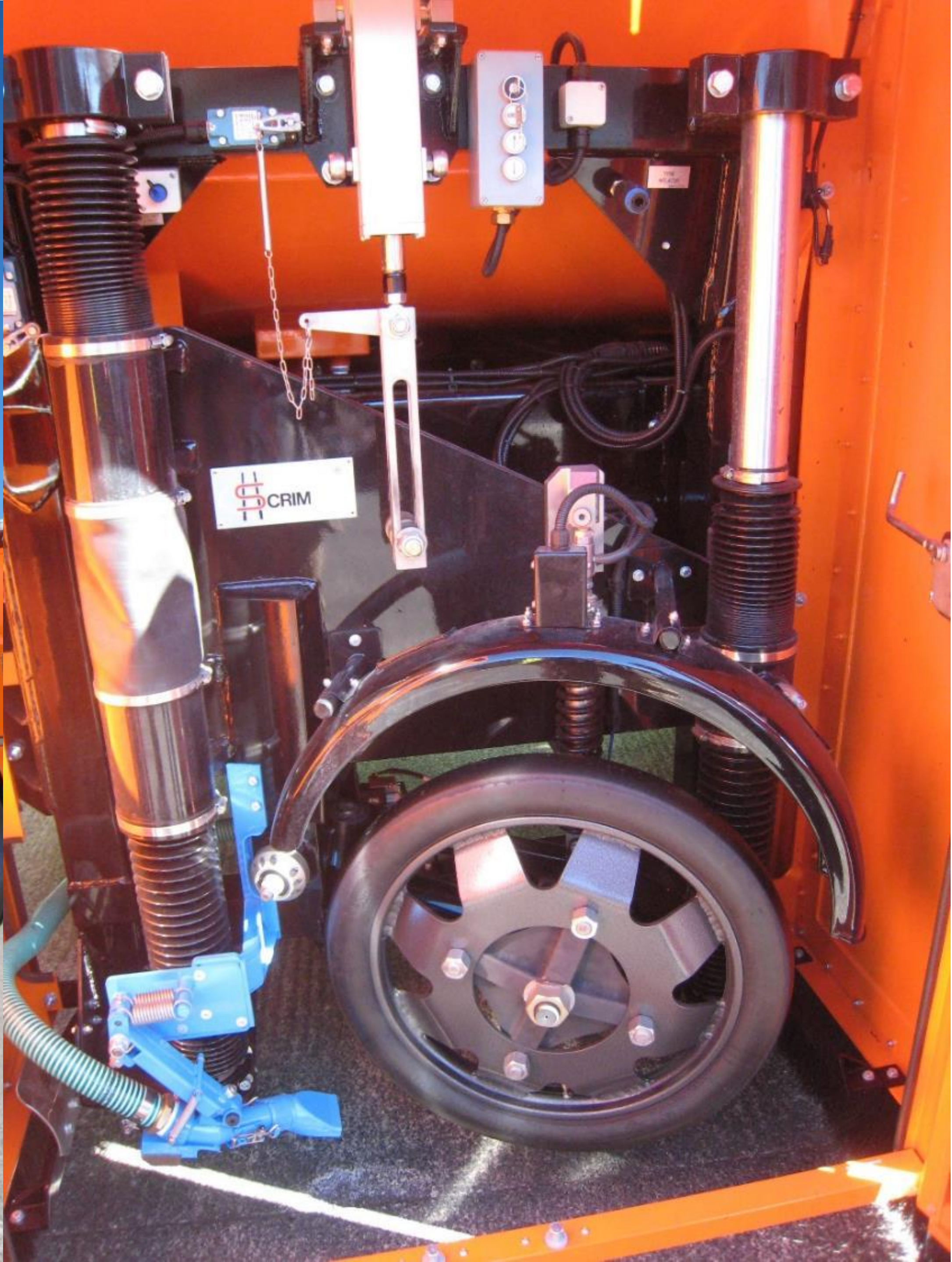
SURVEYING
SCRIM
Virginia Tech
Transportation Institute

SCRIM

Center for Sustainable and Resilient Infrastructure

VDOT Mini SCRIM

Example of a Pavement Friction Management Program

Network Definition

Subdivide the roadway network into Facility and Site Types based on the AASHTO HSM

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Data Collection & Processing

Collected Network Data:
- Pavement – Friction, Texture, Other Pavement Data
- Other data – Roadway, Traffic, Crash, Geometrics, etc.

Collate Data for Network Analysis and Screening into an appropriate analysis section such as, 0.1-mile Sections

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Network Safety Analysis

Perform Network-Level Safety Analysis using Historical Crash Data:
- Safety Performance Functions (SPFs); Uses Existing Friction and Texture Data-Base Condition
- Empirical Bayes (EB) Estimates

↓

Network Treatment Options

Identify Treatment Options with Friction and/or Surface Texture Improvement:
- Identify Potential Network-Level Pavement Treatment Strategies to Implement
- Estimate Construction Costs
- Estimate Friction Improvement

↓

Network-Level Screening using Benefit-Cost Analysis

Identify Potential Candidates for Friction Improvement
- Measured Friction < Friction Improvement
- Considers Friction Demand and Surface Texture
- Safety Performance Functions (SPFs) Integrated with Friction and Surface Texture

Evaluate and Recommend Treatments to Improve Friction
- Use SPF-EB Approach and Predict Potential Crash Reductions for All Sites and Each Treatment Option
- Estimate Treatment Costs and Crash Reduction Savings for Sites
- Compute Total Savings And Benefit-Cost Ratio (BCR)
- Categorize Selected Sites into Treatment Options Based on Largest B/C and B/C>1.0
- Note: Pavement Surface Type/Friction CMFs can be used to Identify Crash Reductions

Identify Pavement Sections for Detailed Investigation

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Detailed Site Investigation

Evaluate Identified Pavement Sections to Determine Crash Contributing Factors and Appropriate Treatments:
- Consider Crash Type (Roadway/Lane Departure, Intersections, etc.)
- Evaluate Non-friction Related Items
- Assess Pavement Friction Characteristics
- Select Treatment, Determine B/C

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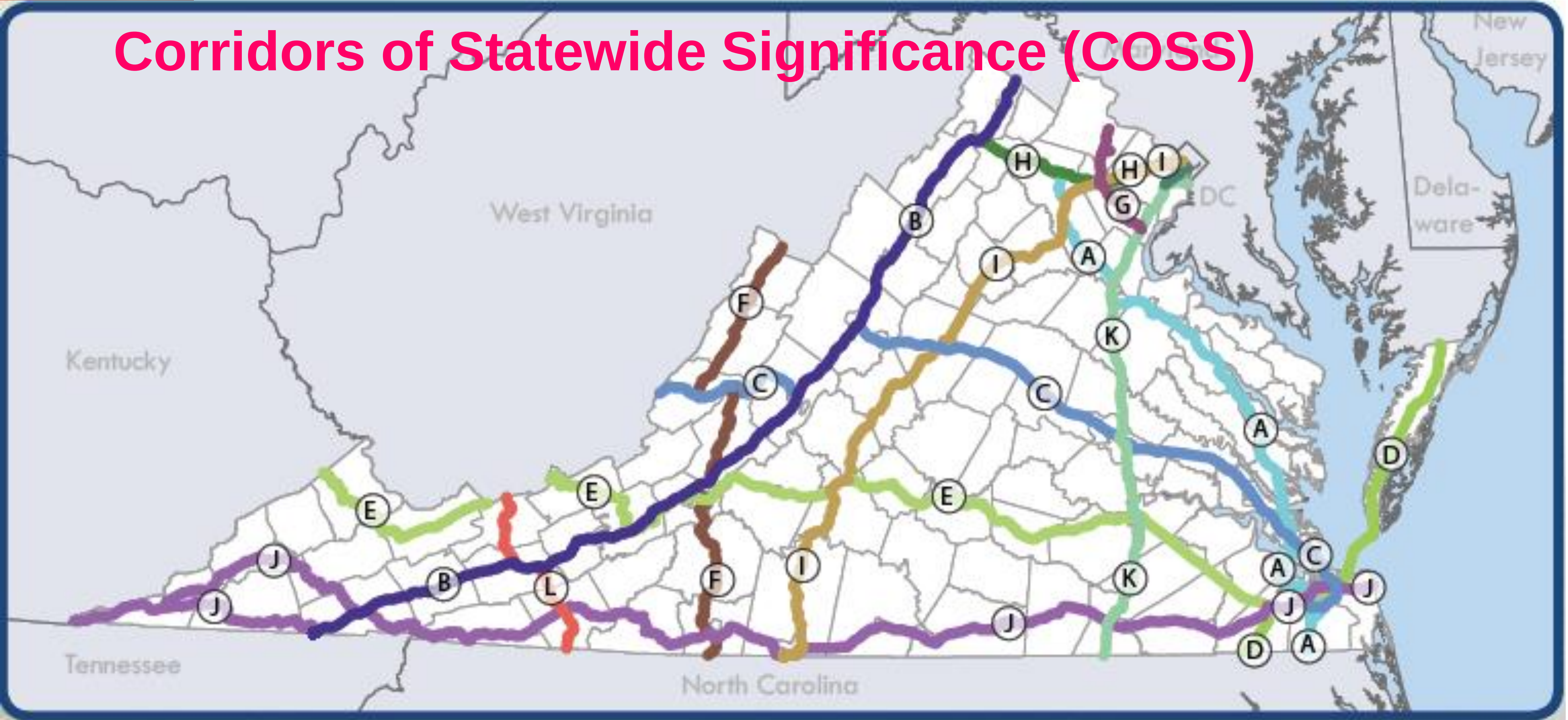
Corridors of Statewide Significance (COSS)

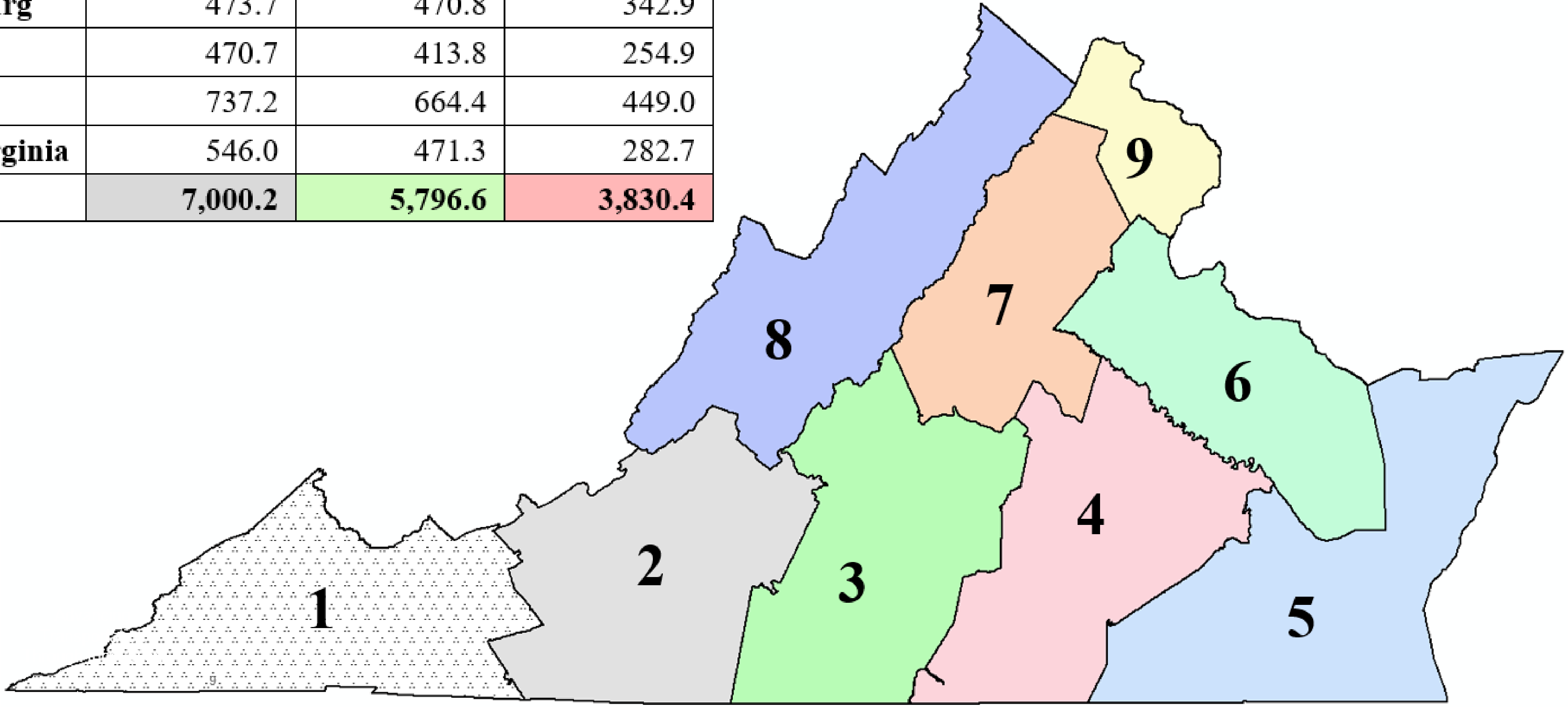


VTrans 2035

- (A) Coastal Corridor (Route 17)
- (B) Crescent Corridor (I-81)
- (C) East-West Corridor (I-64)
- (D) Eastern Shore Corridor (Route 13)
- (E) Heartland Corridor (US 460)
- (F) North Carolina to West Virginia Corridor (Route 220)
- (G) North-South Corridor (New)
- (H) Northern Virginia Corridor (I-66)
- (I) Seminole Corridor (Route 29)
- (J) Southside Corridor (Route 58)
- (K) Washington to North Carolina Corridor (I-95)
- (L) West Mountain Corridor (I-77)

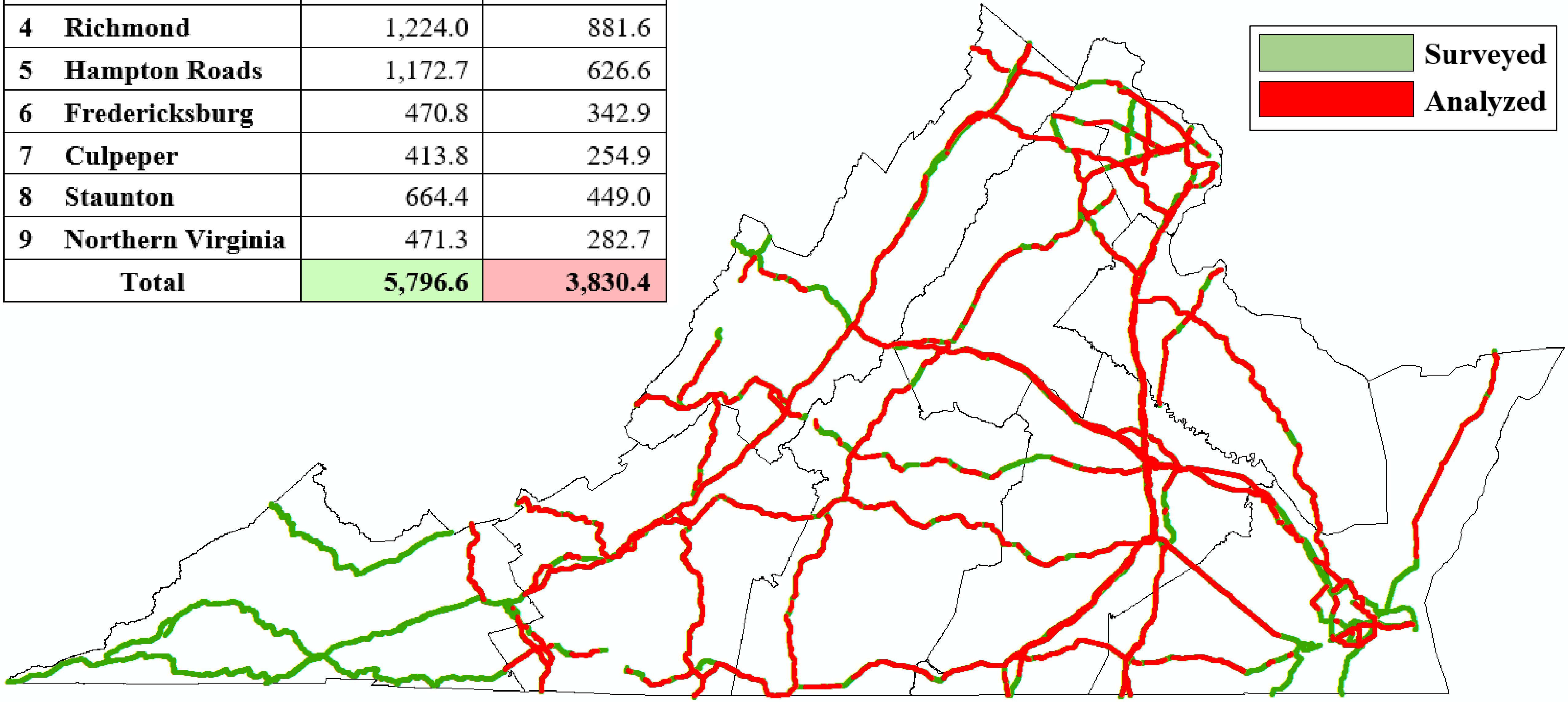
CoSS PFM Network

District	Measured	Surveyed	Analyzed
1 Bristol	892.2	62.3	47.0
2 Salem	841.0	794.4	590.4
3 Lynchburg	544.1	522.9	355.3
4 Richmond	1,249.5	1,224.0	881.6
5 Hampton Roads	1,245.7	1,172.7	626.6
6 Fredericksburg	473.7	470.8	342.9
7 Culpeper	470.7	413.8	254.9
8 Staunton	737.2	664.4	449.0
9 Northern Virginia	546.0	471.3	282.7
Total	**7,000.2**	**5,796.6**	**3,830.4**



CoSS
Surveyed & Analyzed Networks

District		Surveyed	Analyzed
1	Bristol	62.3	47.0
2	Salem	794.4	590.4
3	Lynchburg	522.9	355.3
4	Richmond	1,224.0	881.6
5	Hampton Roads	1,172.7	626.6
6	Fredericksburg	470.8	342.9
7	Culpeper	413.8	254.9
8	Staunton	664.4	449.0
9	Northern Virginia	471.3	282.7
Total		**5,796.6**	**3,830.4**



Statewide

Network Analysis

Surveyed Network: 5,796.6 miles or **10,407.3 lane-miles**

Analyzed Network

	Miles	**Lane-Miles**	
DGAC	2,184.6	5,034.6	(55.8%)
THMACO	66.6	157.8	(1.7%)
SMA	965.4	2,382.5	(26.4%)
MICRO	452.0	1,006.6	(11.2%)
PCCP	161.8	439.7	(4.9%)
TOTAL	**3,830.4**	**9,021.2**	

Observed Crashes: 67,492

Model Development & Economic Analysis

SPF Equation

$$\lambda_i = \exp\left(-0.005 + \sum_{j=1}^{k} \beta_j N_{ij}\right)$$

where $\boldsymbol{\lambda_i}$ = Expected number of crashes for section *i*.

$\boldsymbol{\beta_0}$ = Intercept parameter (-0.005)

$\boldsymbol{\beta_j}$ = Parameters for *j* independent variables.

$\mathbf{N}_{\boldsymbol{ij}}$ = Value of model variable *j* for section *i*.

Safety Performance Function (SPF)

Model Variables	***β***	***p*-value**	**Model Variables**	***β***	***p*-value**
Intercept	-0.005	1.00	Interaction Term(s):		
ln(AADT)	0.266	0.00	SFN40 × Route Type	0.039	0.00
Friction (SFN40)	-0.094	0.00	SFN40 × Texture	-0.042	0.00
Texture (MPD-mm)	1.482	0.02	SFN40 × Grade (%)	—	—
Divided	-0.114	0.79	SFN40 × Cross-slope (%)	-0.005	0.01
Intersections & Ramp Access Points	1.474	0.00	SFN40 × Curvature (1/m)	26.741	0.00
Route Type	-1.407	0.00	SFN40 × Intersections/Ramp Access	-0.011	0.04
Pavement Surface Mix			SFN40 × Divided Roadway	0.025	0.00
SMA	-0.982	0.00	SFN40 × Number of Travel Lanes	0.010	0.01
MICRO	1.821	0.00	SFN40 × Pavement Surface Mix		
PCCP	-1.538	0.00	*SFN40 × SMA*	0.015	0.03
Grade (%)	—	—	*SFN40 × MICRO*	-0.037	0.00
Cross-slope (%)	0.295	0.00	*SFN40 × PCCP*	0.019	0.06
Curvature (1/m)	-991.525	0.00			
Number of Travel Lanes	0.057	0.77			

Note: Indicator variable reference value for route type is primary and pavement surface mix is DGAC.

Economic Analysis

Step 1: Calculate the Number of Crashes Untreated (estimated) & Treated (Predicted)

Compute **SPF**$_{Treated}$ using the value of friction listed in the table:

Treatment Option	SFN40 Improvement
DGAC	60
SMA	55
MICRO	65
PCCP with CDG	60
HFST	80

Step 2: Compute EB Treated: $EB_{Treat} = \frac{SPF_{Treat}}{SPF_{Untreat}} \times EB_{Untreat}$

Step 3: Predicted Crash Reduction: $CR = EB_{Untreat} - EB_{Treat}$

Step 4: CR Savings = CR × $146,304

Crash Severity	Observed Crashes		2016 Comprehensive Unit Costs	Network Crash Costs
K	96	(0.5%)	$11,295,402	$1,084,358,592
A	779	(4.4%)	$654,967	$510,219,293
B	3,856	(21.9%)	$198,492	$765,385,152
C	553	(3.1%)	$125,562	$69,435,786
O	12,324	(70.0%)	$11,906	$146,729,544
Total	**17,608**		—	**$2,576,128,367**

Average Cost/Crash: $2,576,128,367 ÷ 17,608 = 146,304

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Economic Analysis

Step 5: Estimate Treatment Costs: [Cost / Lane / 0.1-mile] × Lane Count

Treatment Option	Cost per Lane-0.1 mi
DGAC	$6,588
SMA	$8,525
MICRO	$1,870
PCCP with CDG	$4,224
HFS	$19,000

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Economic Analysis

Step 6: Treat sections with B/C ≥ 1.0: $B/C = \frac{\text{CR Savings}}{\text{Estimated Treatment Cost}}$

Treatment Selection Criteria

- **Interstate:**
  1. SMA: Asphalt Surfaces
  2. PCCP CDG: PCCP Surfaces
- **Primary:**
  1. Latex (Micro): SMA & DGAC < 6 years
  2. PCCP CDG: PCCP
  3. DGAC: Latex (Micro) Surfaces
  4. Surfaces > 5 years
     - SMA: SMA
     - DGAC: DGAC

Statewide Economic Analysis Results

Savings per sections >	Number of Treated Sections							Predicted Crash Reductions	Treatment Cost	Total Savings
	DGAC	THMACO	SMA	Micro	CDG	HFS	Total			
$5.0 M	4	0	0	2	0	0	6 (0.02%)	269 (0.40%)	$83,683	$39,281,997
$4.0 M	1	0	0	3	0	2	6 (0.02%)	180 (0.27%)	$129,042	$26,890,772
$3.0 M	8	1	1	10	0	5	25 (0.07%)	594 (0.89%)	$494,300	$85,752,551
$2.0 M	28	11	6	23	0	18	86 (0.22%)	1,413 (2.12%)	$1,746,113	$204,446,152
$1.0 M	158	59	67	68	1	101	454 (1.19%)	4,625 (6.96%)	$11,136,212	$613,602,926
$0.5 M	301	160	168	171	4	328	1,132 (2.96%)	5,867 (8.82%)	$28,413,626	$782,176,426
Total	**500**	**231**	**242**	**277**	**5**	**454**	**1,709 (4.46%)**	**12,949 (19.48%)**	**$42,002,975**	**1,752,150,825**

Statewide Findings

1. 56% of Network is DGAC.
2. Around 53% of the Analyzed Network had crashes.
3. Friction was significant in most district SPF models.
4. Based on the SPF, the higher the treatment value of friction, the higher the predicted crash reduction.
5. Crash costs were derived with 2018 FHWA recommendations; treatment costs were provided by VDOT.

Statewide
Conclusions and Recommendations

1. The analysis found 1,709 sections with possible friction enhancements; predicted 12,949 crash reduction with total savings per section > $500k.
2. Total treatment cost is $42M with total savings of $1.75B with a BCR of 43:1
3. VTTI will work with VDOT to develop procedures for both project- and network-level testing and reporting using Virginia's newly acquired CFME vehicle.

Statewide Conclusions and Recommendations

4. **VTTI will develop safety analysis and networking screening procedures with the Safety Office in the Traffic Engineering Division.**
5. **VTTI will develop screening procedures that will address the use of speed, crashes, and other information to evaluate possible friction and macrotexture enhancement treatments.**
6. **VTTI will work with VDOT to create a data table and import procedures for friction and related safety data as collected on the VDOT network.**

Questions

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