Corridor-Level Performance Measures to Support Cross-Asset Resource Allocation Strategies in Highway

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Virginia Sustainable Pavement Research Consortium (VA-SPARC)

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Outline

o **Introduction**

o **Methodology**

o **Case study**

o **Applications**
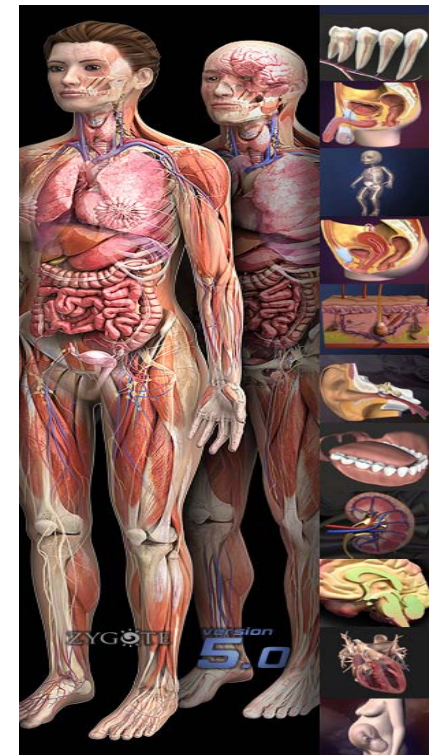
o **Summary/conclusion**

Introduction - What's the Problem?

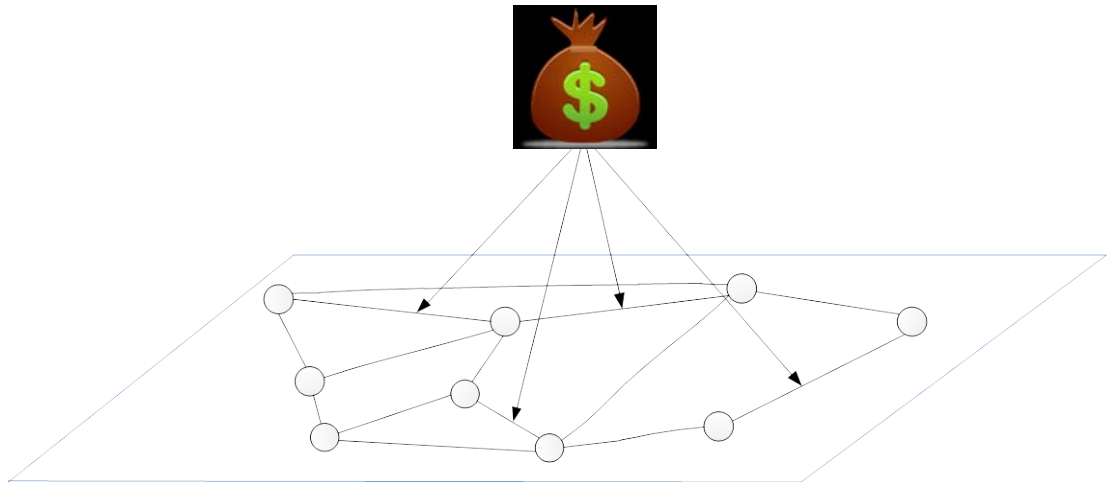✓ **Common "quality" scale is needed for cross-asset resource allocation**

✓ **But each component contributed to the overall wellbeing of our road segment**
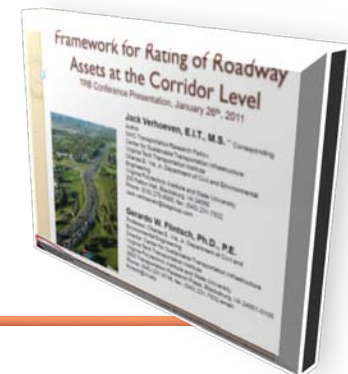
→ **Corridor** → **System**

Objective

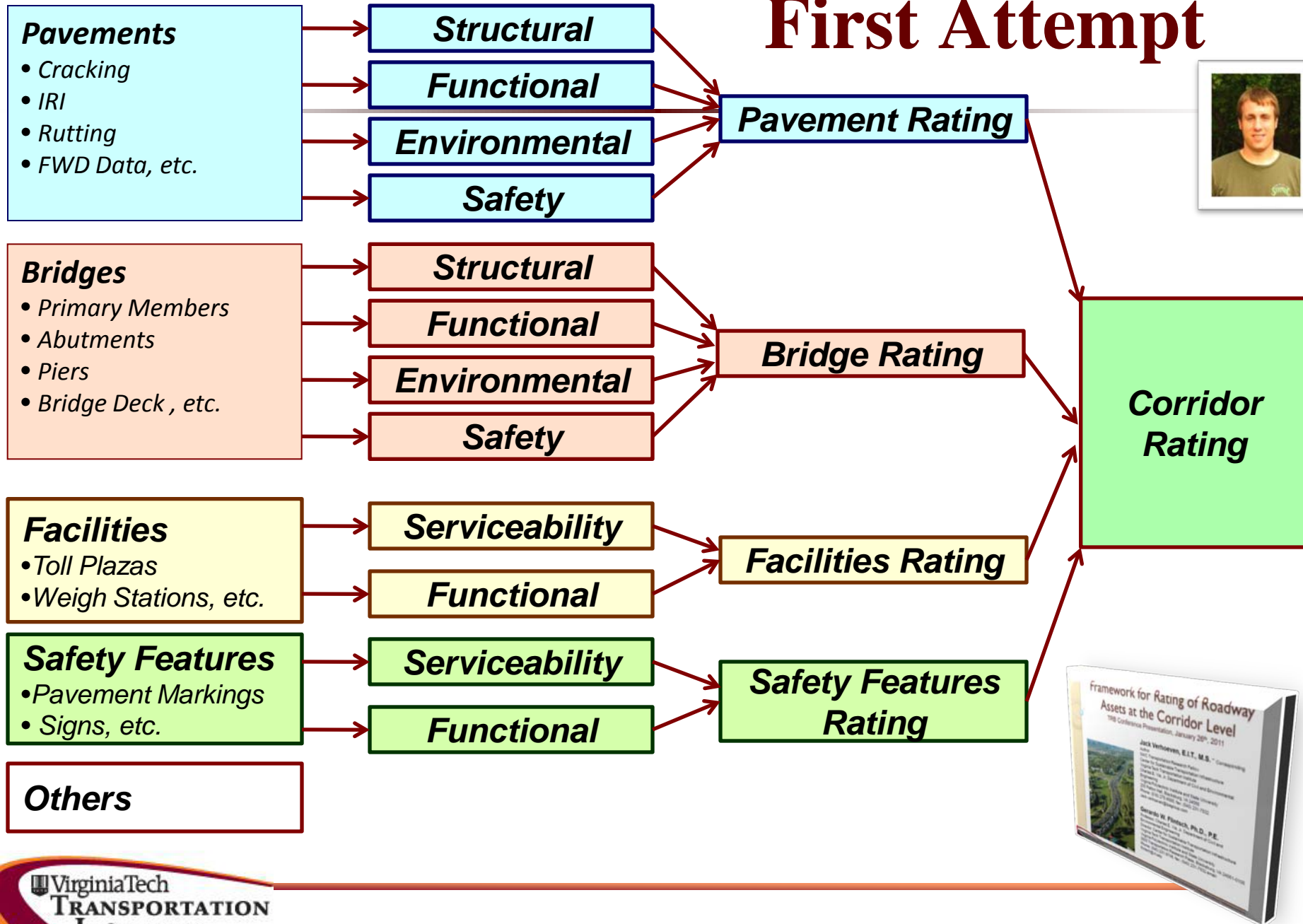o **Developing a framework to aggregate performance of roadway assets into overall roadway performance measures**

  ✓ **for cross-asset resource allocation, tradeoff analysis, etc.**

Background

- Performance measures already developed for individual assets

- Several studies trying to aggregate all different types of performance measures for one asset

  - ✓ (e.g. COST method)

- Aggregating performance of multiple assets into corridor-level (system-level) performance measures
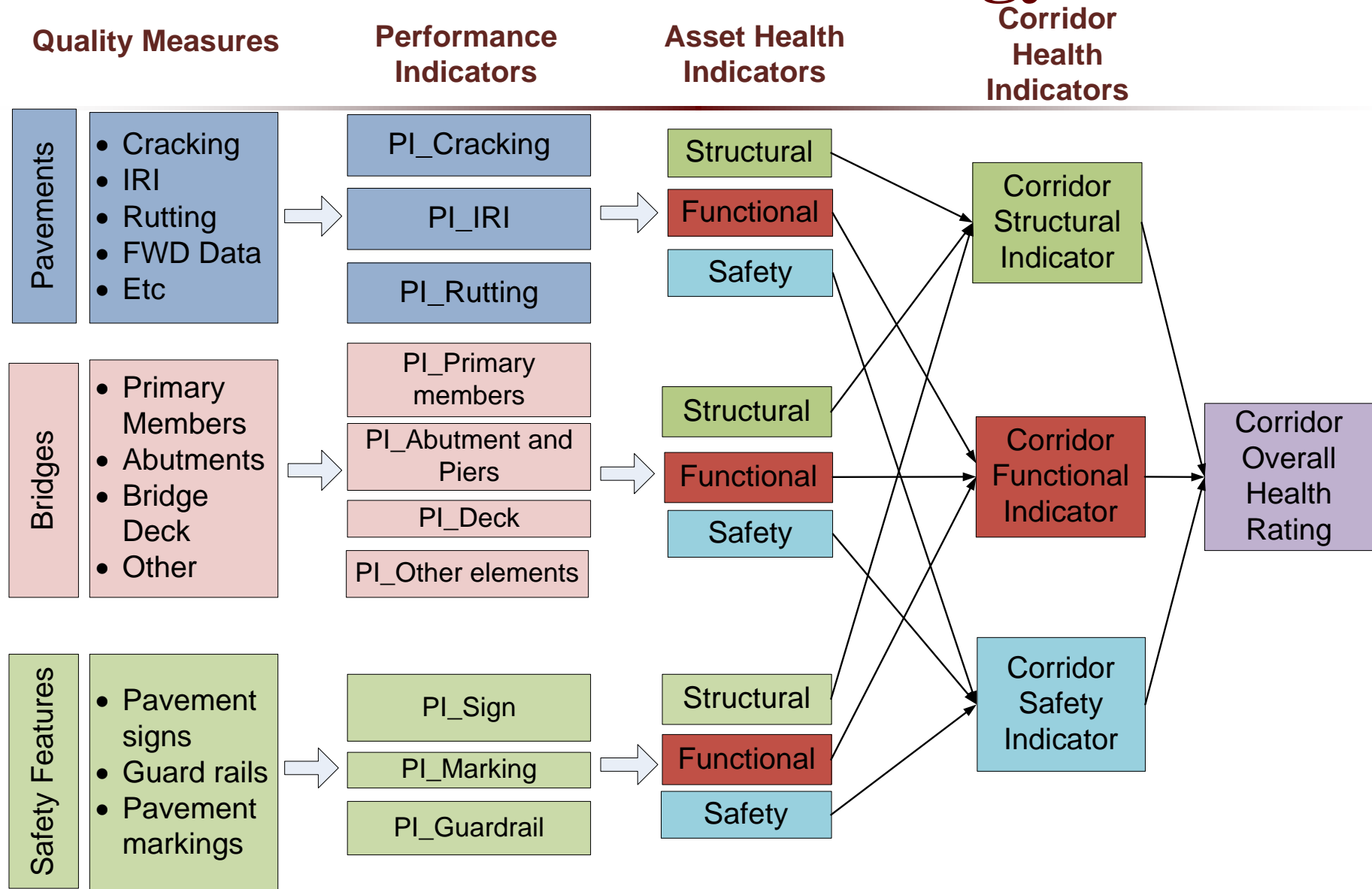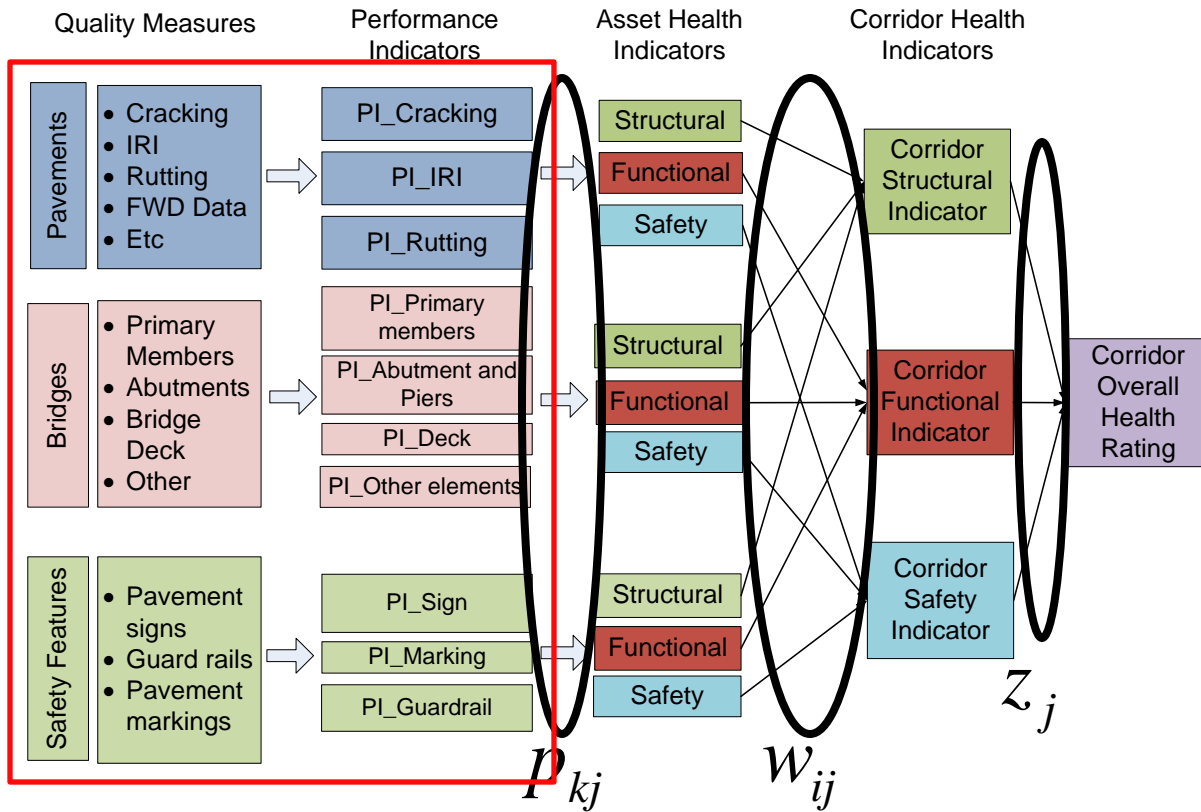
  - ✓ Not yet explicitly addressed

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First Attempt

Pavements
- *Cracking*
- *IRI*
- *Rutting*
- *FWD Data, etc.*

→ **Structural**
→ **Functional**
→ **Environmental**
→ **Safety**

→ **Pavement Rating**

Bridges
- *Primary Members*
- *Abutments*
- *Piers*
- *Bridge Deck, etc.*

→ **Structural**
→ **Functional**
→ **Environmental**
→ **Safety**

→ **Bridge Rating**

Facilities
- *Toll Plazas*
- *Weigh Stations, etc.*

→ **Serviceability**
→ **Functional**

→ **Facilities Rating**

Safety Features
- *Pavement Markings*
- *Signs, etc.*

→ **Serviceability**
→ **Functional**

→ **Safety Features Rating**

Others

→ **Corridor Rating**

Framework for Rating of Roadway Assets at the Corridor Level

Performance Indicators (PI)

o **Value based on quality measures**

o **Reflects remaining time until quality measure exceeds acceptable limits**

o **Scale 0 to 10**

- ✓ **10 – "Like New" condition**
- ✓ **0 – Quality measure at unacceptable level**

o **Calculation different for each asset**

- ✓ **Different quality measures available**

o **Only step of method which is asset dependent**

Revised Methodology

Quality Measures | Performance Indicators | Asset Health Indicators | Corridor Health Indicators

Pavements
- Cracking
- IRI
- Rutting
- FWD Data
- Etc

PI_Cracking
PI_IRI
PI_Rutting

Structural
Functional
Safety

Bridges
- Primary Members
- Abutments
- Bridge Deck
- Other

PI_Primary members
PI_Abutment and Piers
PI_Deck
PI_Other elements

Structural
Functional
Safety

Safety Features
- Pavement signs
- Guard rails
- Pavement markings

PI_Sign
PI_Marking
PI_Guardrail

Structural
Functional
Safety

Corridor Structural Indicator
Corridor Functional Indicator
Corridor Safety Indicator

Corridor Overall Health Rating

Calculations

Quality Measures | Performance Indicators | Asset Health Indicators | Corridor Health Indicators

Pavements
- Cracking
- IRI
- Rutting
- FWD Data
- Etc

PI_Cracking
PI_IRI
PI_Rutting

Bridges
- Primary Members
- Abutments
- Bridge Deck
- Other

PI_Primary members
PI_Abutment and Piers
PI_Deck
PI_Other elements

Safety Features
- Pavement signs
- Guard rails
- Pavement markings

PI_Sign
PI_Marking
PI_Guardrail

Structural
Functional
Safety

Structural
Functional
Safety

Structural
Functional
Safety

Corridor Structural Indicator

Corridor Functional Indicator

Corridor Safety Indicator

Corridor Overall Health Rating

p_{kj} w_{ij} z_j

k: type of quality measure
j: Health Indicator type
i: Asset type

$$PI\_IRI = \min(10, \max(0, -0.05 \times IRI + 12))$$

$$PI_f = \left[\frac{WEQ_f}{TEQ_f}\right] \times 10 \qquad WEQ_f = \sum EQ_{fi} \times \alpha_i$$

$$AHI_{ij} = \frac{\sum_k PI_{ik} \times p_{kj}}{\sum_k p_{kj}}$$

$$CHI_j = \frac{\sum_i AHI_{ij} \times w_{ij}}{\sum_i w_{ij}}$$

$$COHR = \frac{\sum_j CHI_j * z_j}{\sum_j z_j}$$

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Case Study

- **Pavement** (for every 0.1 mile)
  - ➤ **IRI**
  - ➤ **Rut depth**
  - ➤ **Longitudinal cracks**
  - ➤ **Alligator cracks**
  - ➤ **Transverse cracks**

- **Bridges** (five condition states)
  - ➤ **Primary members**
  - ➤ **Deck**
  - ➤ **Abutment and piers**

- ✓ **I-81 North bound**
- ✓ **Mileage 50-100**
- ✓ **Assets**
  - ✓ **Pavements**
  - ✓ **Bridges**
- ✓ **Measures**
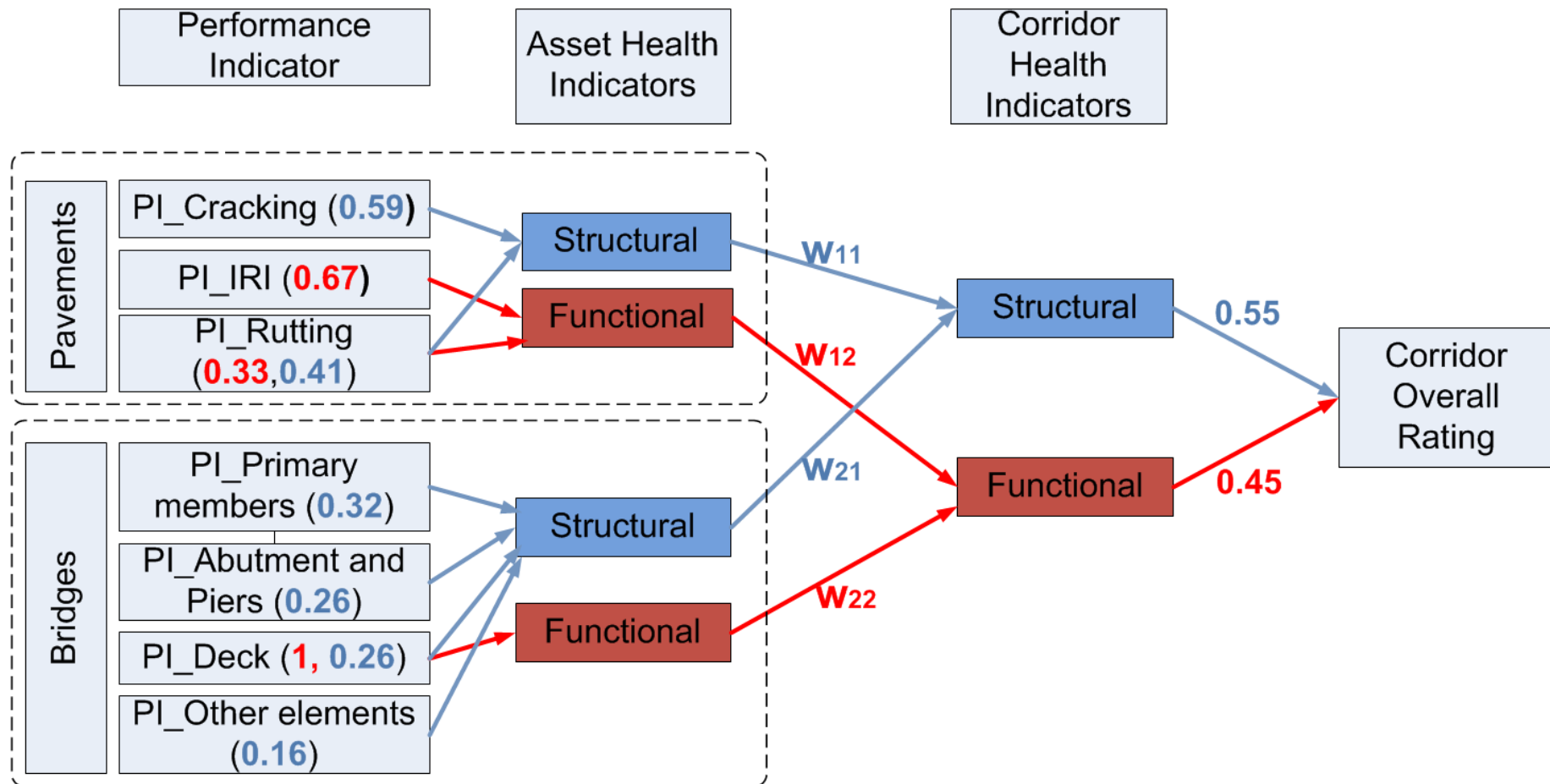 - ✓ **Structural**
  - ✓ **Functional**

Acknowledgement

MP 50-100
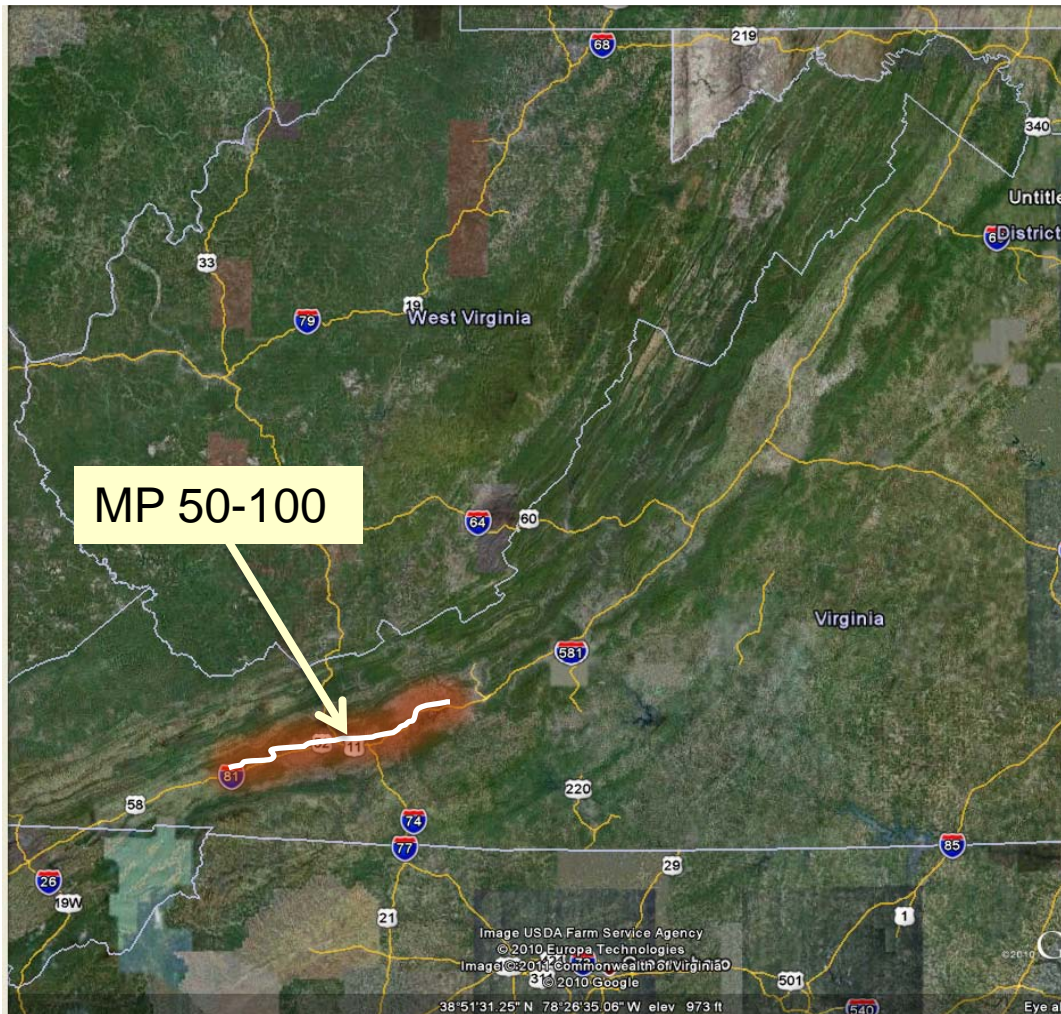
VDOT

- ✓ **Tanveer Chowdhury, Raja Shekharan and William Duke** (Office of Asset Management)

- ✓ **Richard Thompson** (Office of Structure and Bridge)

- ✓ **Jeff Price** (Operations Planning Division)

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Calculations

W12,W22: Functional weight for pavements and bridges are determined based on their surface area

W11, W21: Structural weights determined based on the replacement cost of pavements and bridges

Results - Pavements
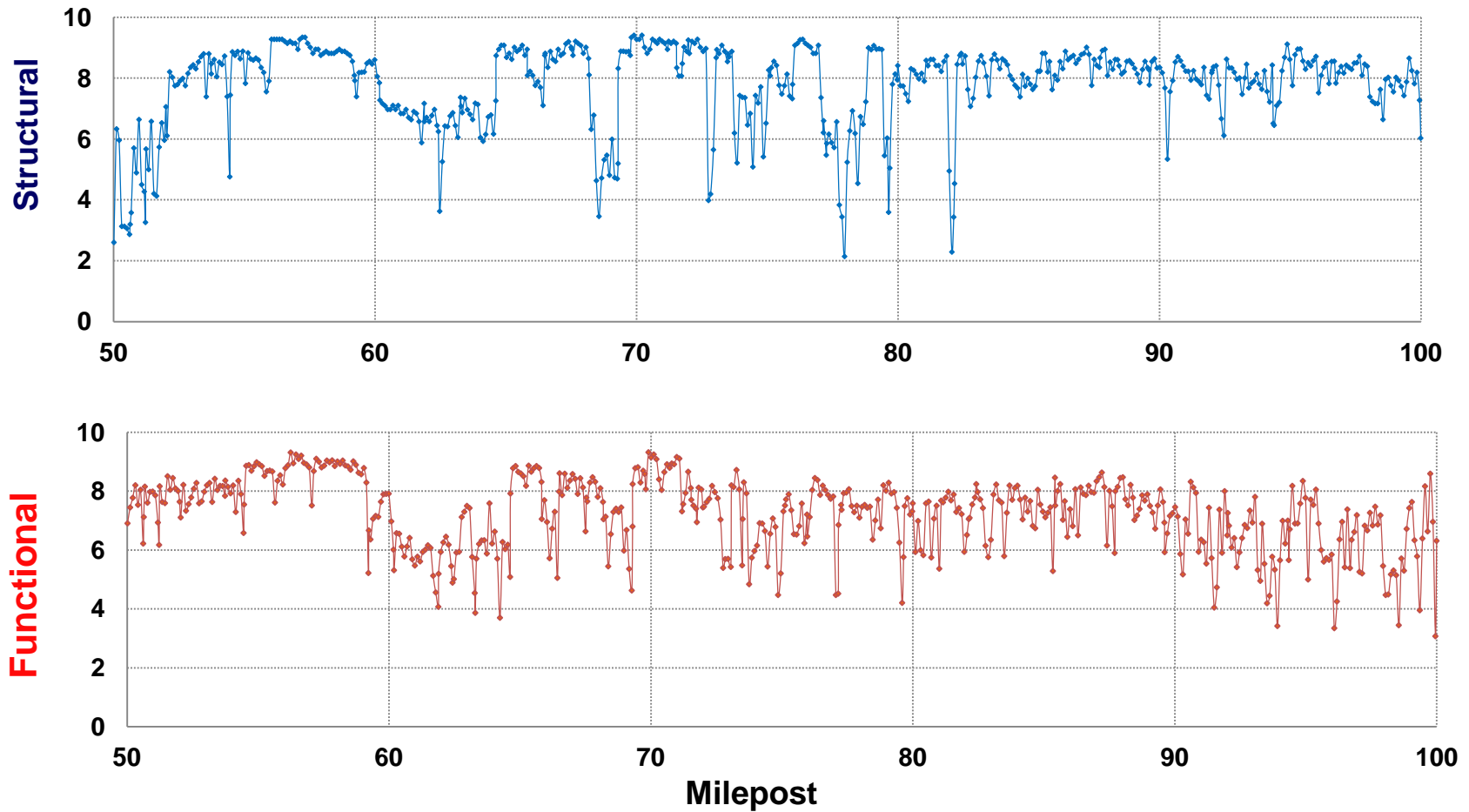
Results - Bridges
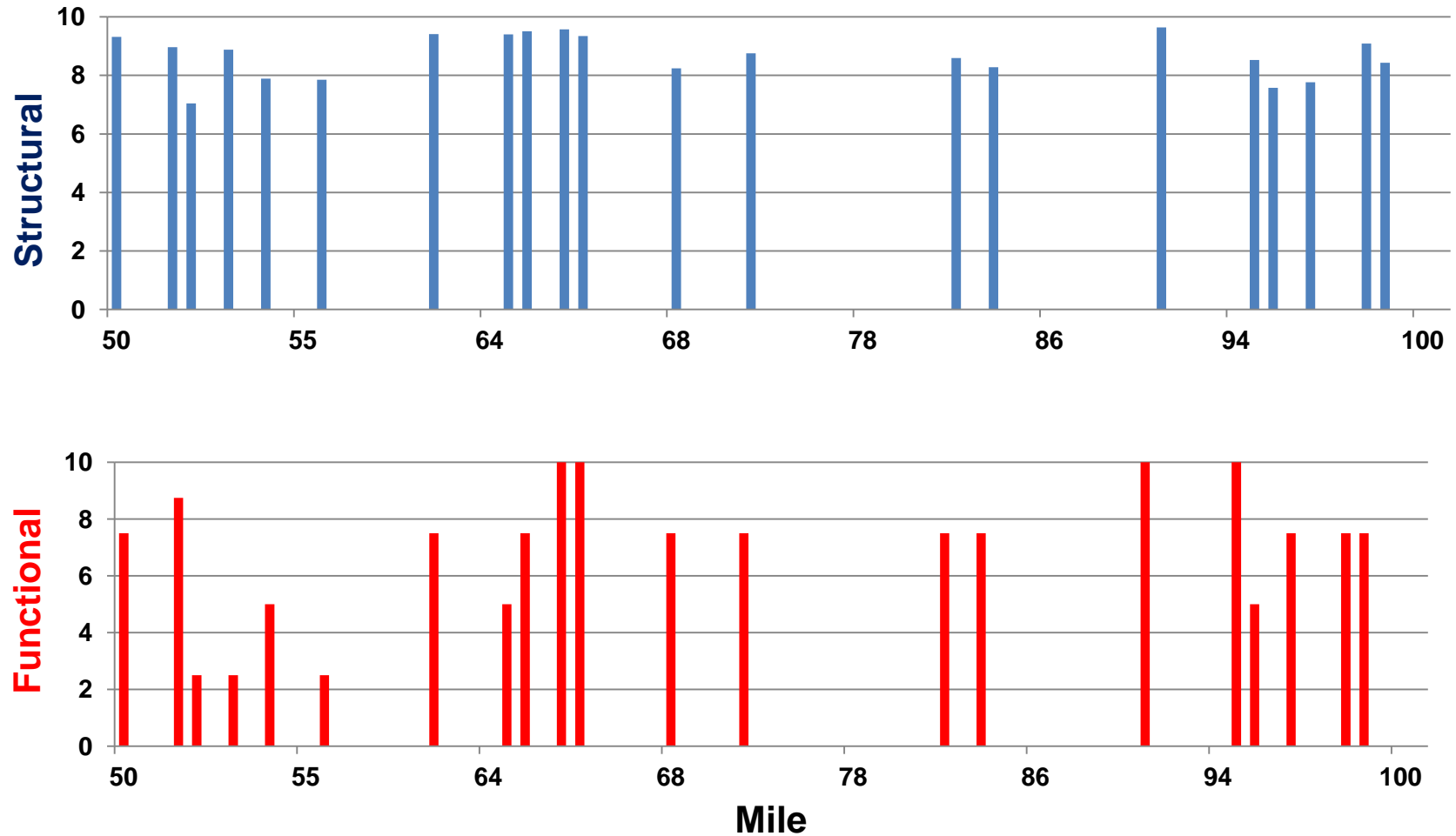
Results (cont.)

Pavements
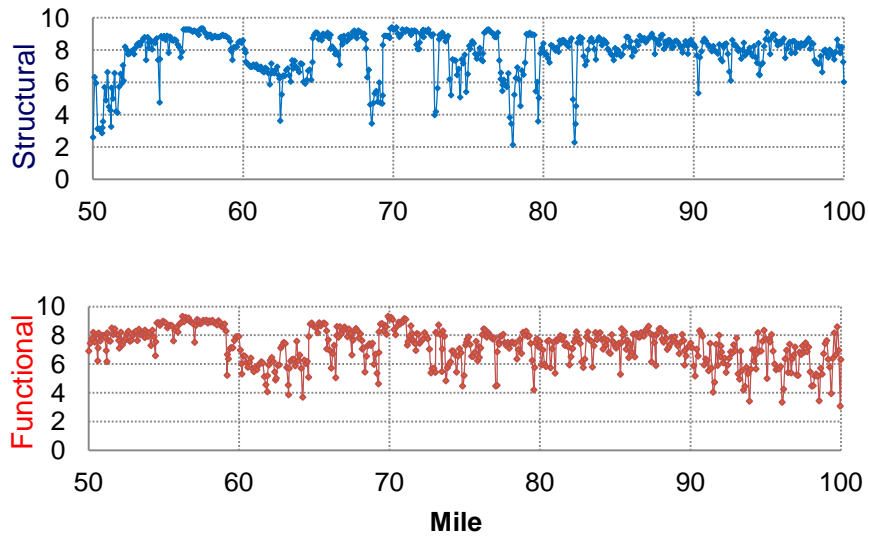
Bridges
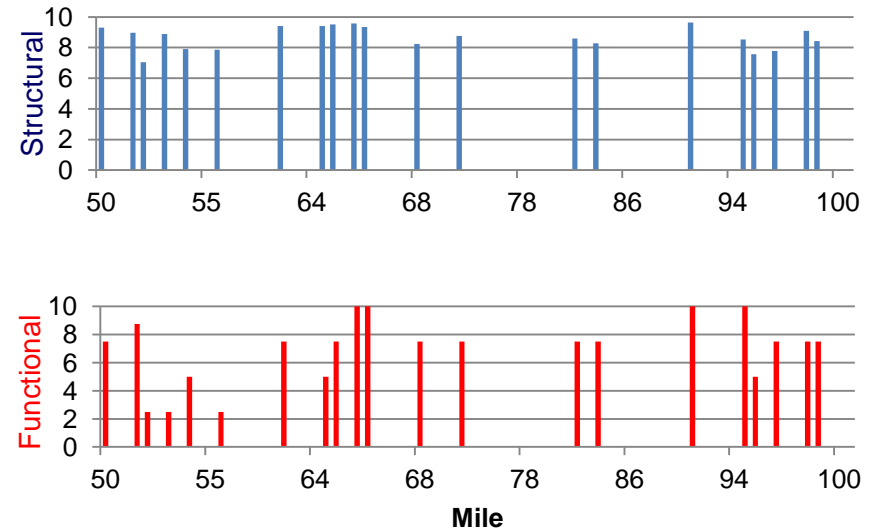
Results (cont.)

Corridor

✓ **Homogenous corridor health indicators**

✓ **Continuous profiles for each indicator**

7.8

7.2

7.6
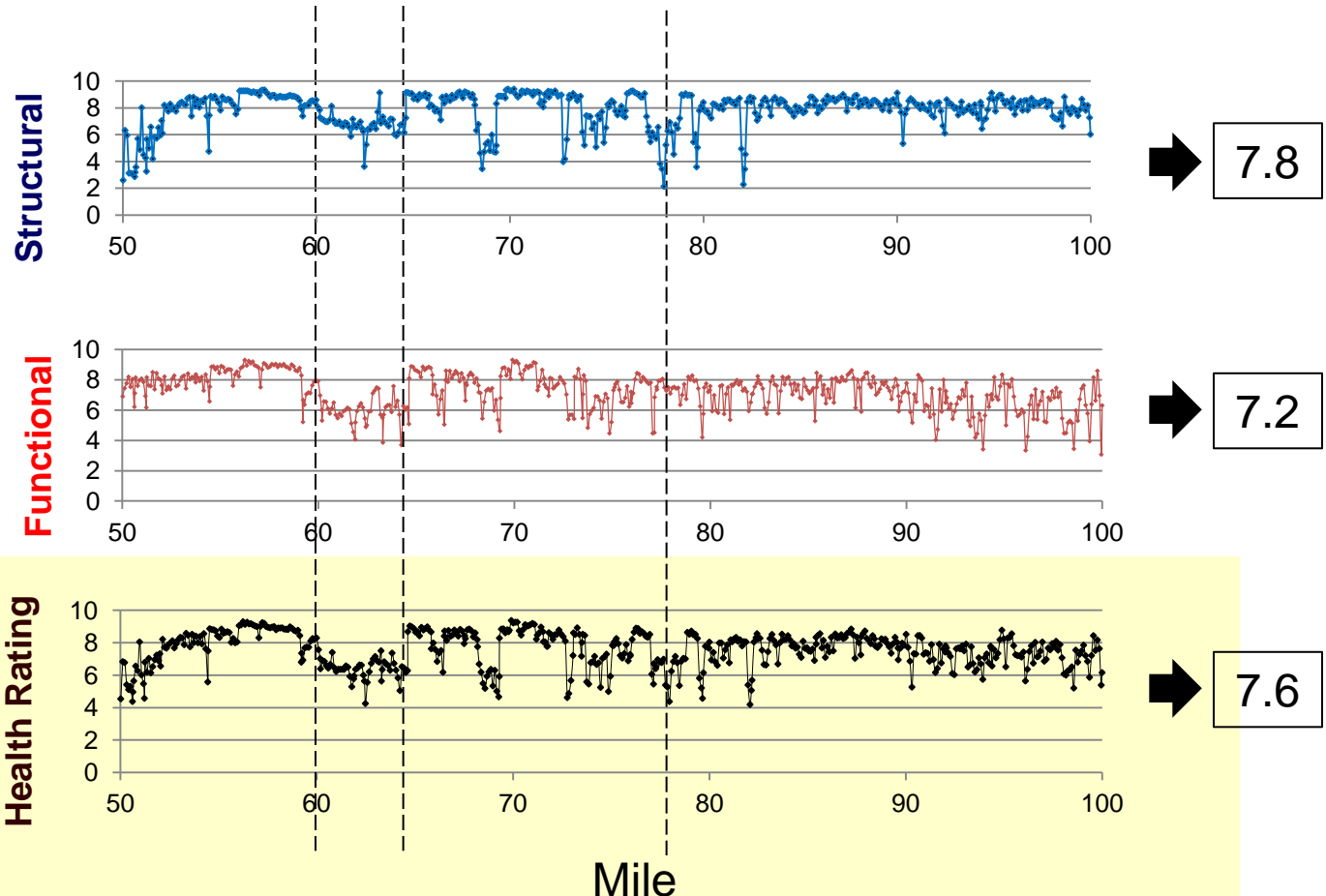
Applications - Resource Allocation
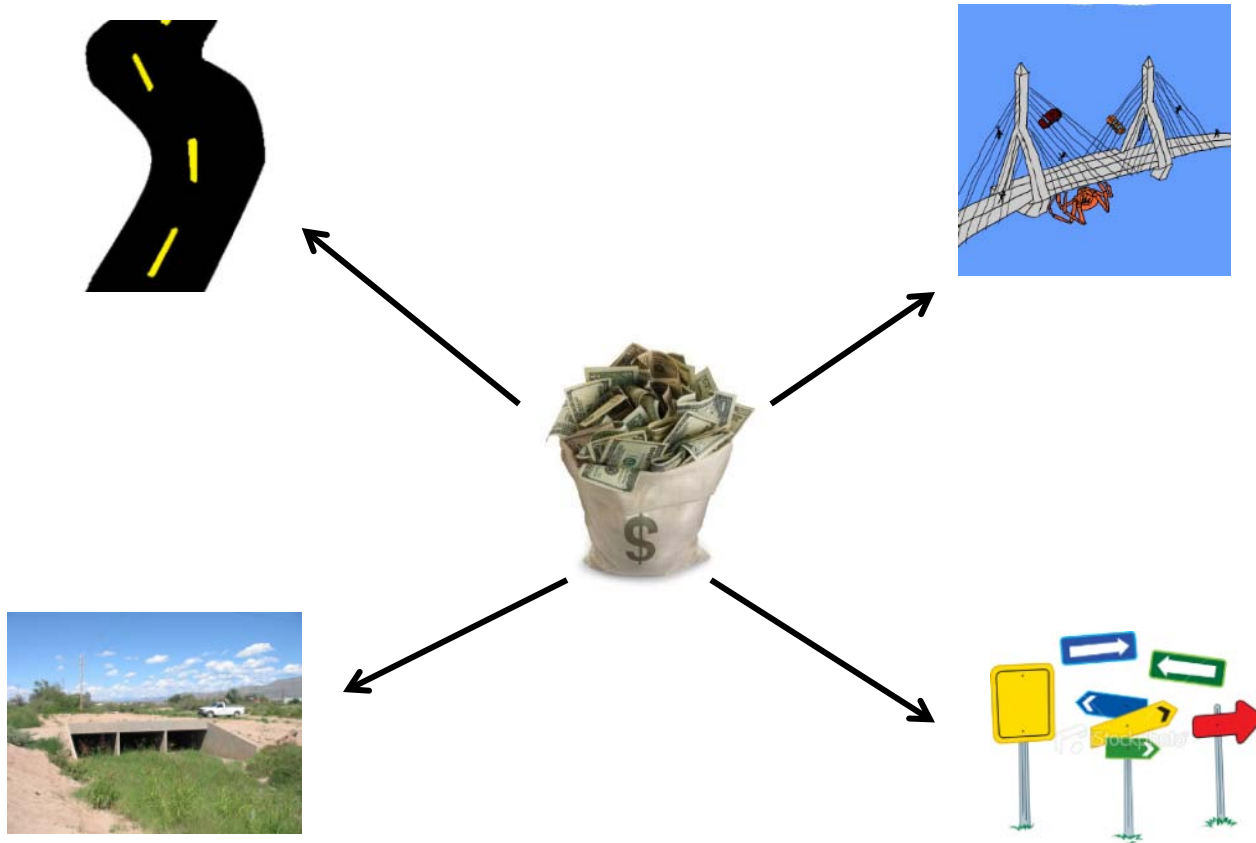
Application (Simplified Example)

✓ **Assets**
  ➤ **Pavements**
  ➤ **Bridges**

✓ **Health Indicators**
  ➤ **Functional**
  ➤ **Structural**

	Pavement	Bridge
Lane. Mile	4	-
Area (ft²)	-	2000
Functional Indicator	6	4
Structural Indicator	5	7
Required Budget ($)	1,500,000	
Available Budget($)	1,000,000	

	Treatment Type	Treatment Cost ($/Lane-mile)	Extended Life (Years)	Maximum Functional Gain (unit)	Maximum Structural Gain (unit)
Pavement	Preventive	10,000	3	1.5	-
	Corrective	80,000	8	5	2
	Restorative	200,000	12	8	5
	Reconstruct/ Rehabilitate	500,000	20	10	10
		Treatment Cost ($/ft²)	Extended Life (Years)	Maximum Functional Gain (unit)	Maximum Structural Gain (unit)
Bridge	Epoxy Overlay	70	6	4	-
	Deck Replacement	120	15	6	1.5
	Heavy Rehab	370	25	8	5
	Reconstruction	1000	40	10	10

Application (Simplified Example)

✓ **Scenario selected**

✓ **Treatment applied based on budget**

✓ **Performance averaged over 5 year analysis period**
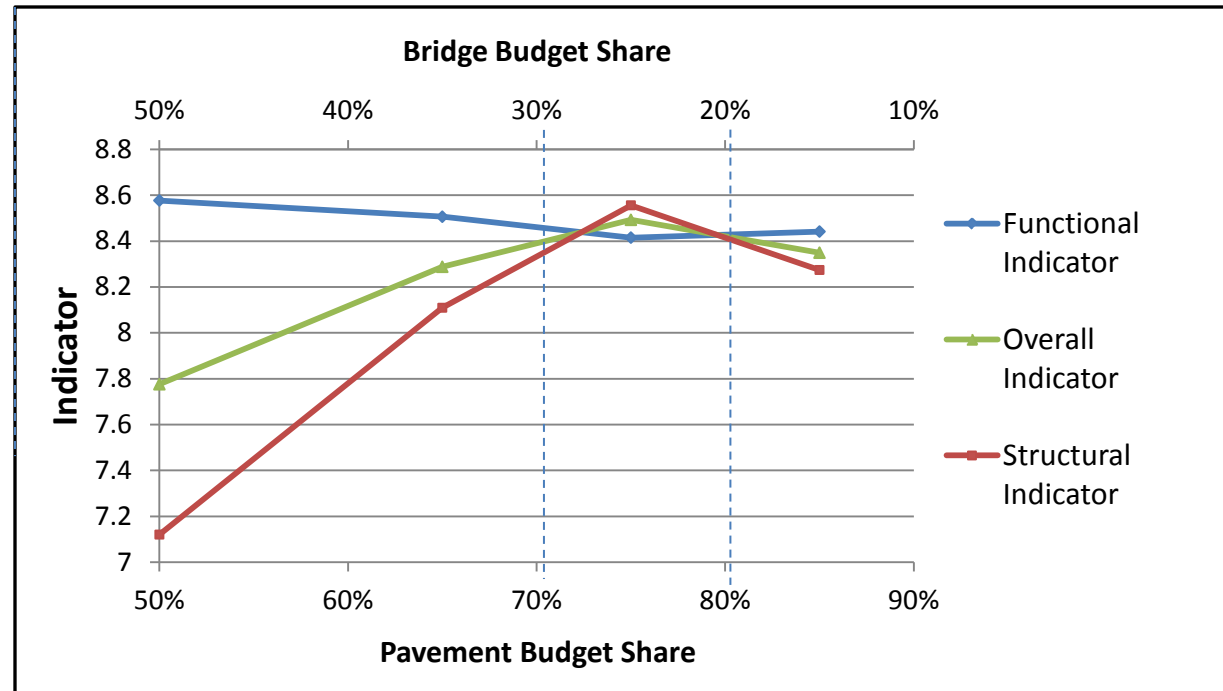
✓ **Optimal allocation**

Future Research

✓ **Consider more assets**

✓ **Consider other performance measures, particularly, safety, and environmental factors**

Conclusion

o **Proposed method for homogenous aggregation of performance measures**

o **For strategic level decision making**

✓ **Comparing investment trade-offs**

✓ **Support cross-asset resource allocation**

9th National Conference on Transportation Asset Management
Making Asset Management Work in Your Organization

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For more information:

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