NCHRP 23-07: Effective Methods for Setting Transportation Performance Targets

TPM Webinar Series

Reliability (Travel Time and Freight), June 8, 2022

ICF

With support from

HIGH STREET

applied pavement TECHNOLOGY

Agenda

- Welcome & Overview of Methods
- Presentation by Iowa DOT + Q&A
- Presentation by Virginia DOT + Q&A
- Discussion

Navigating Zoom

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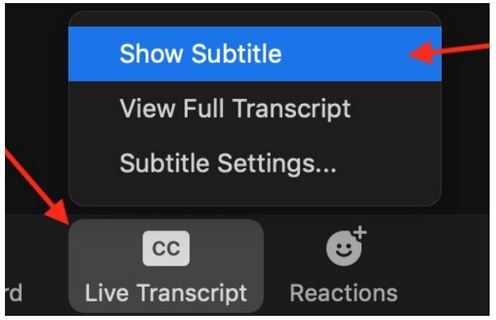
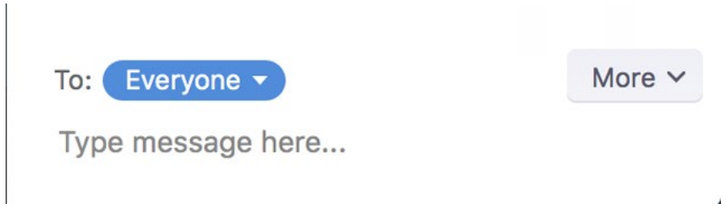


To ask a question, type the question in the chat or click “Raise Hand” to be called on.



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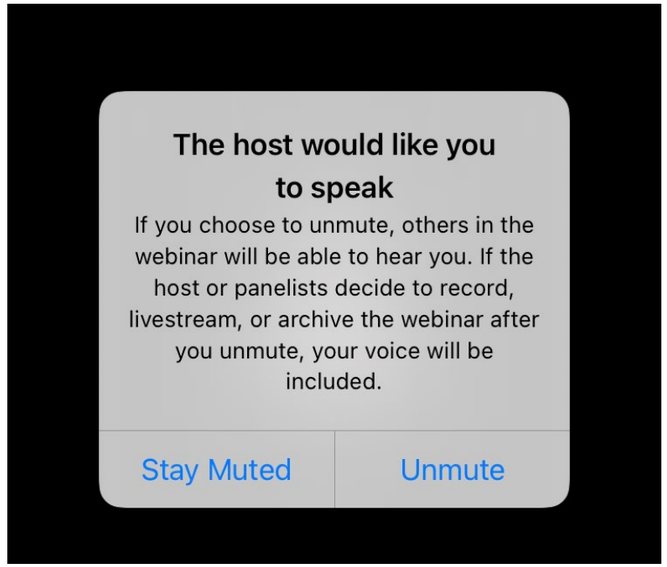


Guidebook Purpose

To help State DOTs and MPOs identify effective methods for setting transportation performance targets.

Guidebook Contents

Types of Target Setting Methods Used

- Policy-Based
  - E.g., annual decrease of 3%
- Historical Trends
  - E.g., based on trend over past 5 years
- Probabilistic and Risk-based Approaches
  - E.g., considering potential variability in performance
- Statistical Models that account for Explanatory Factors
  - E.g., regression model
- Other Tools and Models
  - E.g., pavement management systems

Target setting philosophies

Conservative
Help ensure the agency can attain the target

Realistic/ Predictive
Level most likely to occur

Aspirational
Reflect commitment to improved outcomes

Guidebook Part I: Target Setting Overview and Tips

What Makes a Target Setting Method Effective?

- Ease of Application
- Technical Robustness
- Ease of Communication
- Allows for Policy Consideration

Helps inform investments and strategies by providing information about factors driving performance

Motivates stakeholders and decision makers to engage in discussions about actions to meet targets

Reliability (Travel Time and Freight) Performance Measures

1. Percent of the person-miles traveled on the Interstate that are reliable
2. Percent of person-miles traveled on the non-Interstate NHS that are reliable

Travel Time Reliability

3. Truck Travel Time Reliability (TTTR) Index

Freight Reliability

Guidebook Part II: Target Setting Methods

RELIABILITY

Simpler to implement & communicate

More data-heavy

Method	Strengths	Limitations	Other Considerations
Building off Baseline, with Assumptions Maintaining the baseline level as the target or making an adjustment based on judgement	Simple, easy to communicate and often brings in stakeholders.	No rigorous analytical methods are used for the adjustments.	Method for agencies with limited data. Agency will need to decide which exogenous factors are relevant.
Time-Series Trend Analysis Forecast based simply on historical performance trend	Simple while still being data-driven.	No insights into causes of outcomes. Misses incorporation of new factors that may influence targets in the future.	May result in a worsening target, which can pose communication challenges. Method may be useful for agencies with limited data about exogenous factors.
Trend Plus Other Factors Expands upon trend analysis to account for other factors that may shift future performance	Data-driven; allows for consideration of additional factors.	There may still be no rigorous methods for the adjustments – sometimes adjustments may not be data-driven.	May result in a worsening target. Agency will need to decide which exogenous factors are relevant.
Performance Risk Analysis Uses monthly performance data to calculate a standard deviation and then uses the deviation to assess confidence level to set target	Data-driven; allows for deeper scrutiny of the observed variation in the past performance; helps to make an informed decision on the possible future range for the target	Data may be limited for robust analysis. No insight into causes of outcomes, unless paired with other method. Misses incorporation of new factors that may influence targets in the future.	Using target ranges often seems to lean toward selecting conservative targets where there is a high likelihood of meeting the target.
Segment Risk Analysis Focuses on segment-level data to assess segments that are at risk of shifting across the threshold of a "reliable" segment	Introduces secondary analysis onto the reliability calculation; more customized approach.	Requires additional, somewhat complex analysis of individual segments.	May result in a worsening target.
Statistical Model Regression analysis or tool developed to account for various factors to predict performance; typically applied at the segment level	Fuller understanding of causes of outcomes, fully data-driven, and may support linking the target setting process with decision-making by informing what factors can be influenced	Complex, requiring analytical and data skills, and harder to communicate the method and nuance to stakeholders. May result in a worsening target.	A sophisticated model will require significant data gathering and in depth knowledge of application of statistical models

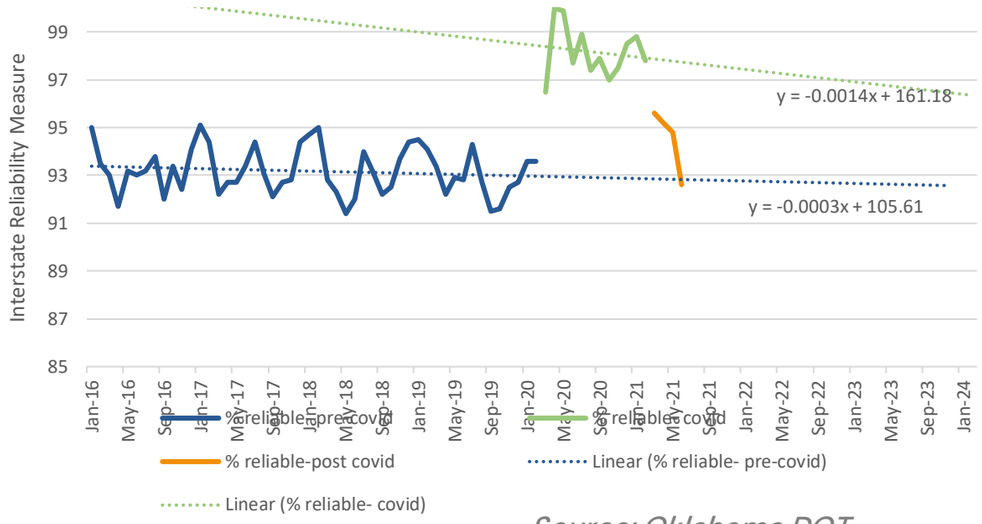
Guidebook Part II: Target Setting Methods

RELIABILITY

1. Building off Baseline
(Simple Data Driven method)

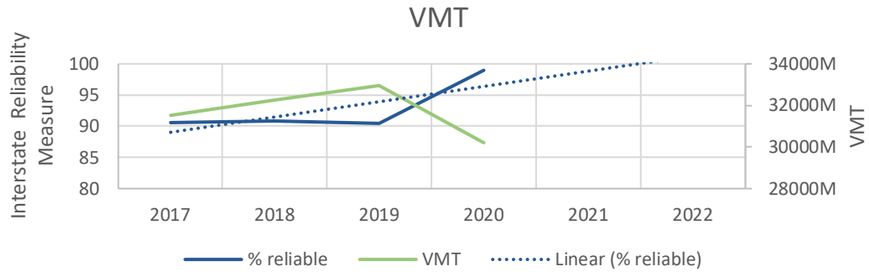
work well for agencies with limited data for trend analysis and limited data on external influencing factors.

2. Time-Series Trend
(statistical analysis)



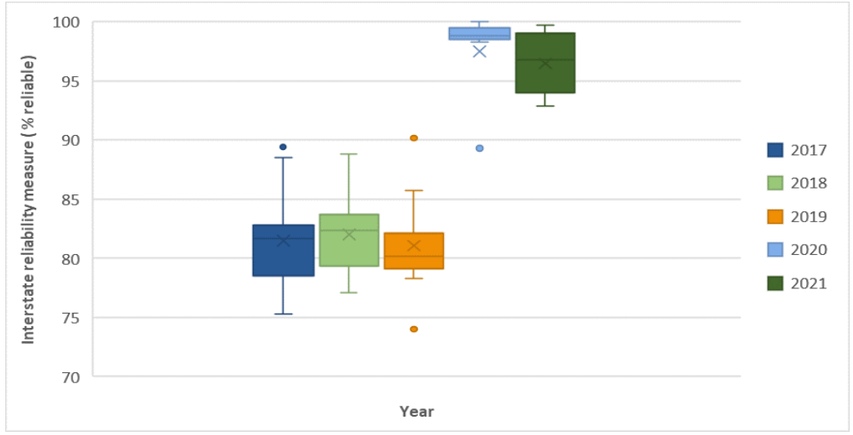
Source: Oklahoma DOT

3. Trend Plus Other Factors
(adjustments from other trends)



Source – Utah DOT

4. Performance Risk Analysis
(Consider Possible Ranges)



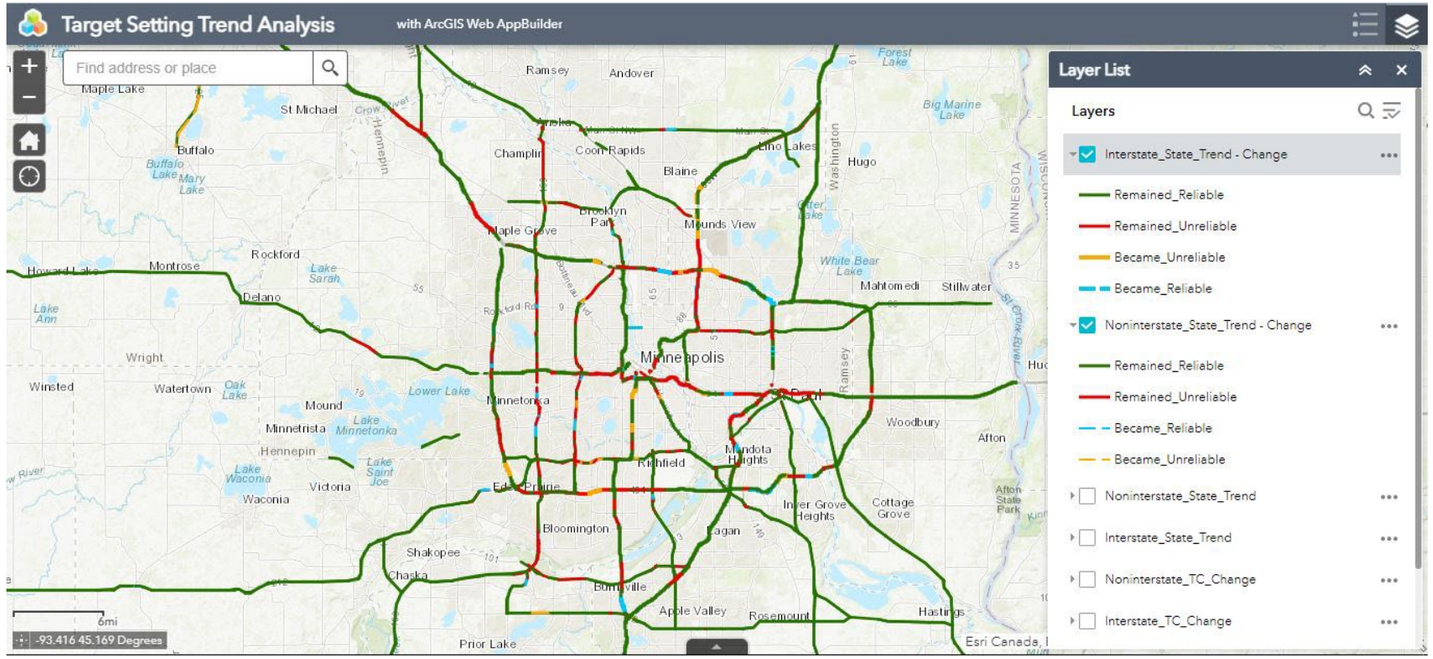
Source: Minnesota DOT

Guidebook Part II: Target Setting Methods

RELIABILITY

5. Segment Risk Analysis

(Analysis of Individual Segments)



Source: Minnesota DOT

6. Statistical Model

(Sophisticated methods)

Predicting performance on segment level based on statistical forecast models

- Remained Reliable (2019 and 2024 LOTTR <1.5)
- Remained Unreliable (2019 and 2024 LOTTR >1.5)
- Became Reliable (2019 LOTTR > 1.5and 2024 LOTTR < 1.5)
- Became Unreliable (2019 LOTTR < 1.5and 2024 LOTTR > 1.5)

Presenters

Iowa DOT

Andrea Whyte

Method:

Travel Time and Freight Reliability Target Setting Approach

Virginia DOT

Sanhita Lahiri and Simona Babiceanu

Method:

Travel Time Reliability Target Setting Approach

Iowa DOT PM3 Targets

NCHRP 23-07 Workshop: Effective Travel Time and Freight Reliability Target Setting Methods

June 8, 2022

Overview

- Overall FHWA target-setting approach
- Initial PM3 target setting, 4-year target adjustments
- PM3 data for 2017-2021
- Lessons learned and moving forward

General approach to FHWA targets in 2018

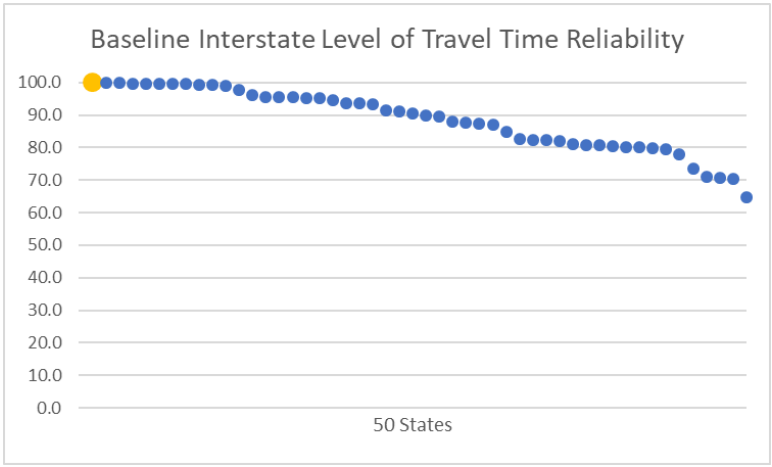
Risk-based target setting approach

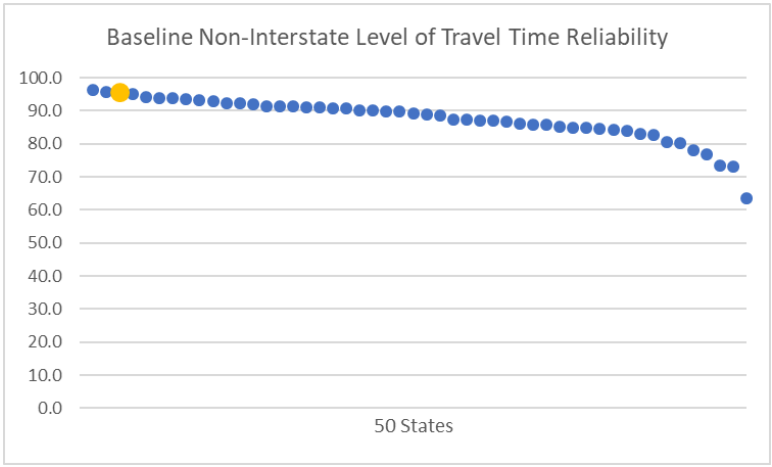
Develop prediction intervals, focus on probability of achieving targets

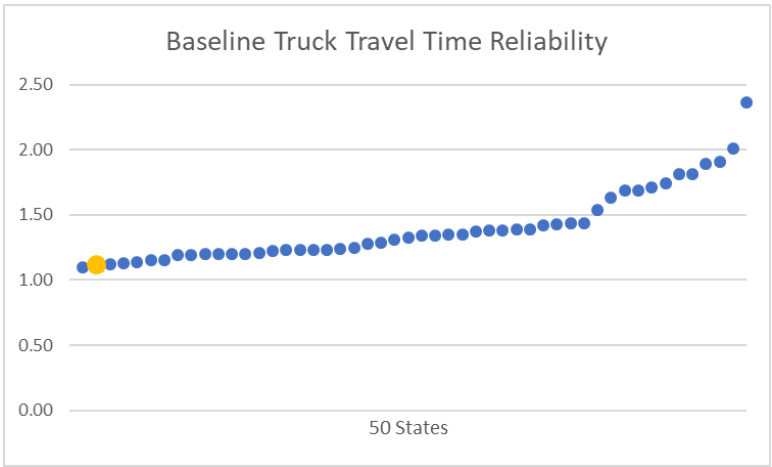
Method A: Develop trend model based on available history		Method B: Use available data to learn as much as we can about variability			
PM1 (Safety)		PM2 (Bridge)		PM2 (Pavement)		PM3 (System Performance & Freight)	
Data from 1987 - 2017	Selected 75% confidence	Data from 2004 – 2016	Selected 75% confidence	Data from 2014 – 2017	Selected 75% confidence	Data from 2017	Selected 75% confidence

2017 baselines for PM3

- Iowa's baselines (in yellow) were extremely reliable
- Without data history, likely future performance was unclear







Source: FHWA State Performance Dashboard

Initial target setting in 2018

- Only one year of data available; very high reliability
- Used monthly variability as a proxy for annual variability
- Calculated standard deviation
- Assumed normal distribution model
- Applied confidence level and rounding

Figure 1: Statistical analysis for the Interstate LOTTR measure

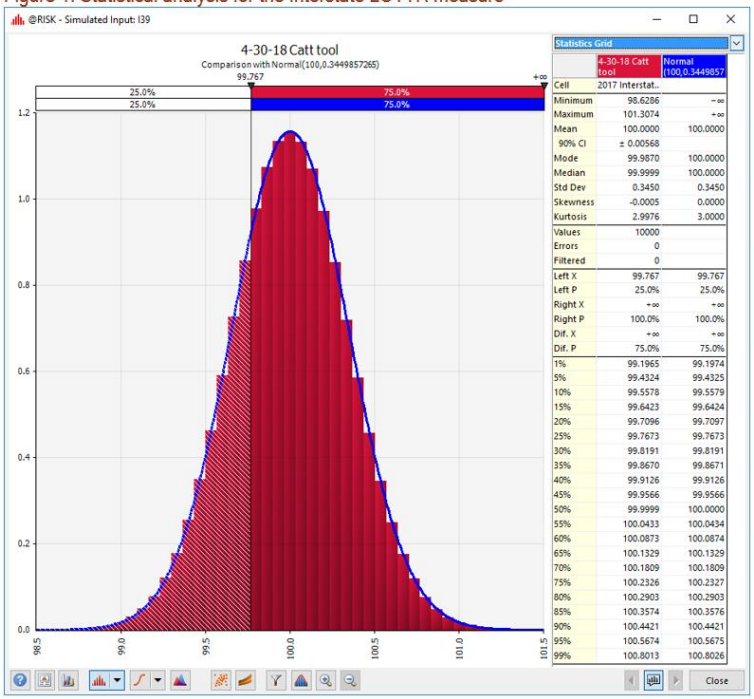


Table 1: Level of travel time reliability for the Interstate System
Monthly and annual output and targets at various confidence levels

Month	CATT tool output
January 2017	100.0
February 2017	99.5
March 2017	100.0
April 2017	99.7
May 2017	99.7
June 2017	98.8
July 2017	99.8
August 2017	100.0
September 2017	99.7
October 2017	100.0
November 2017	100.0
December 2017	99.9
2017 Annual Baseline	**100.0**
Standard Deviation	**0.345**
Confidence Level	**Target**
70 percent	99.82%
75 percent	**99.77%**
80 percent	99.71%
85 percent	99.64%
90 percent	99.56%
95 percent	99.43%

Adjusted targets in 2020

- Updated analysis with two additional years of annual and monthly data
- Changed distribution models for two measures; followed same process to calculate targets

Figure 1: "Best fit" distribution for the monthly Interstate LOTTR data

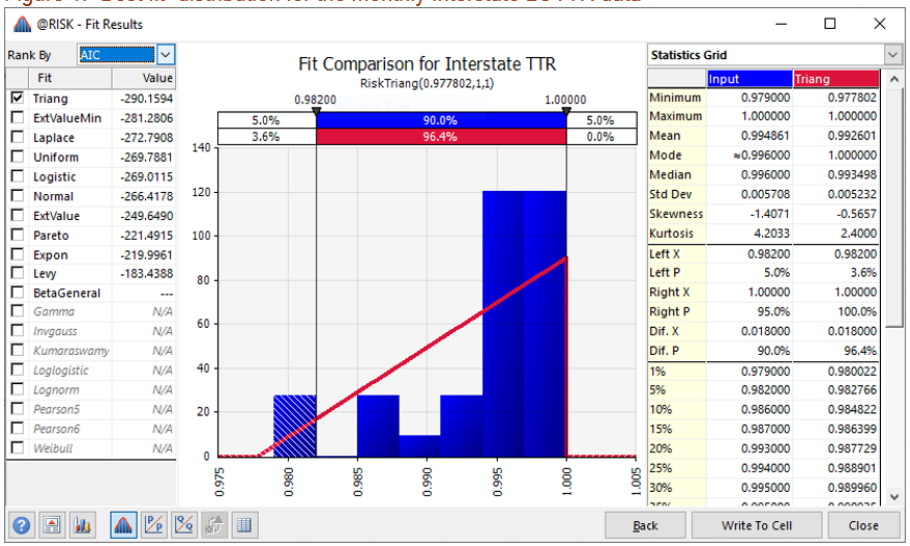
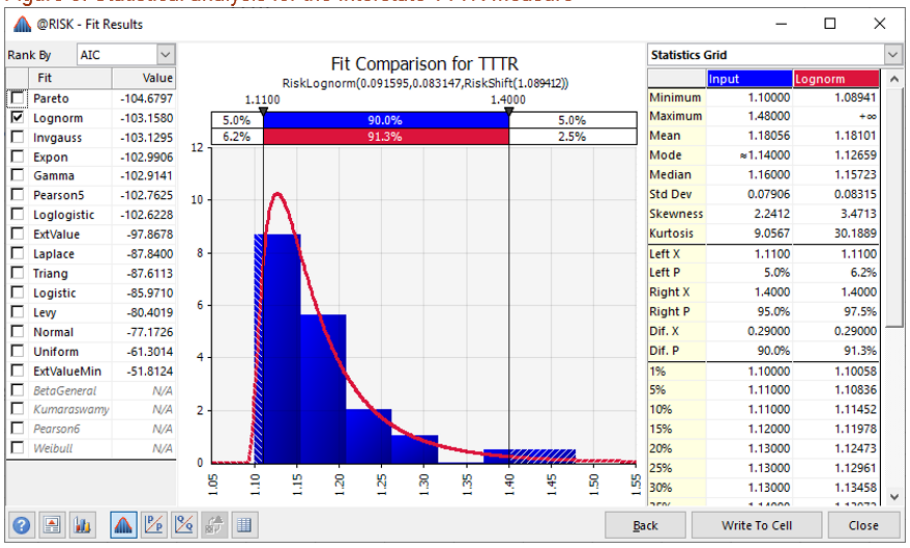


Figure 3: Statistical analysis for the Interstate TTTR measure

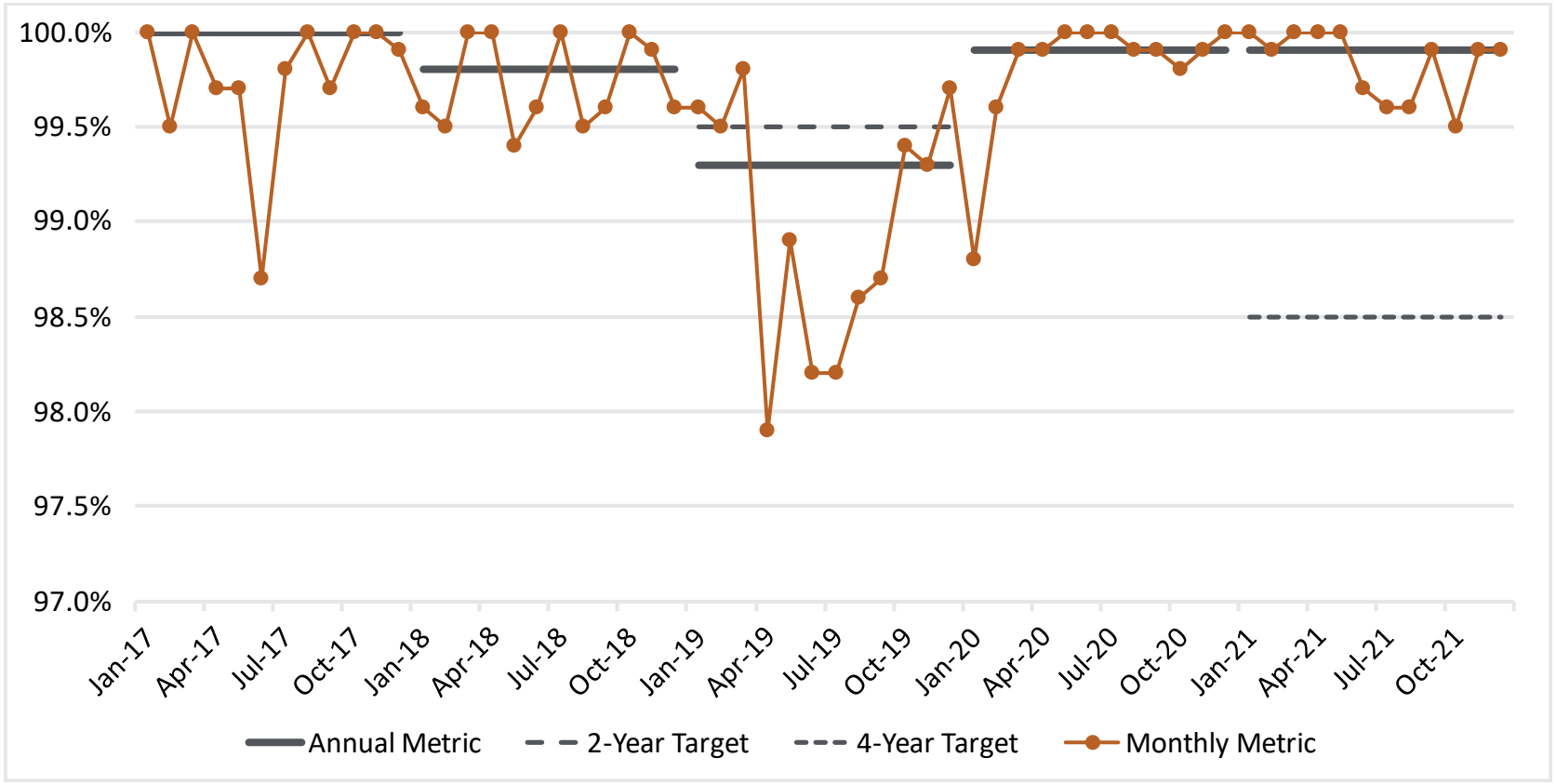


https://iowadot.gov/systems_planning/Planning/Federal-Performance-Management-and-Asset-Management

PM3 Measures/Targets for 2018-2021 performance period

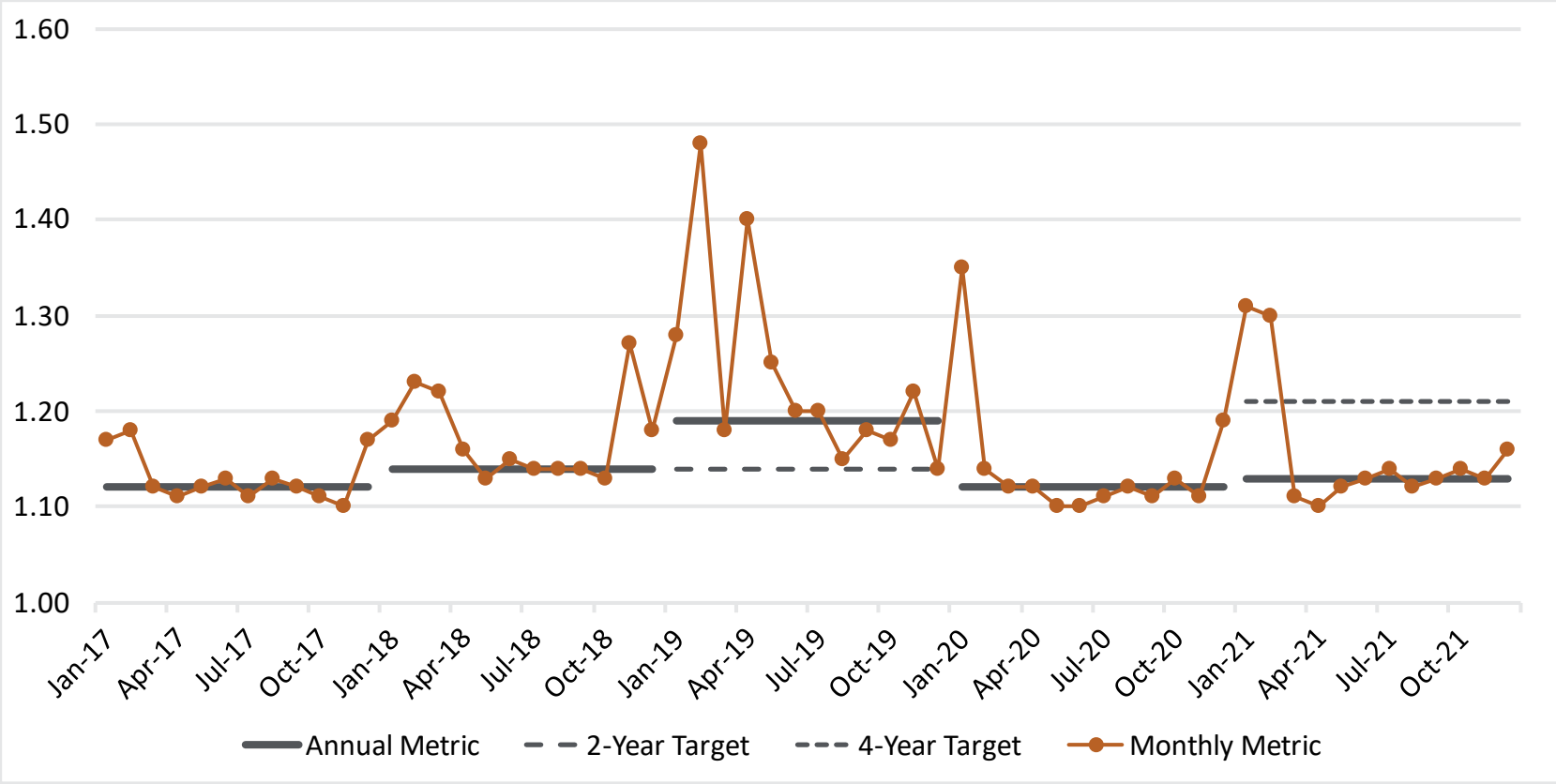
		First performance Period						
Performance measure	**2017** *Baseline*	**2018**	**2019** *Mid-year*	**2020**	**2021** *Final year*	**2-yr target**	**4-yr target** *Original*	**4-yr target** *Adjusted*
Person-miles traveled on the **Interstate** that are reliable	100.0%	99.8%	99.3%	99.9%	99.9%	99.5%	99.5%	98.5%
Person-miles traveled on the **non-Interstate NHS** that are reliable	95.5%	96.3%	96.3%	96.8%	96.5%	N/A	95.0%	
Truck Travel Time Reliability (TTTR) Index	1.12	1.14	1.19	1.12	1.13	1.14	1.14	1.21

Interstate Level of Travel Time Reliability 2017-2021



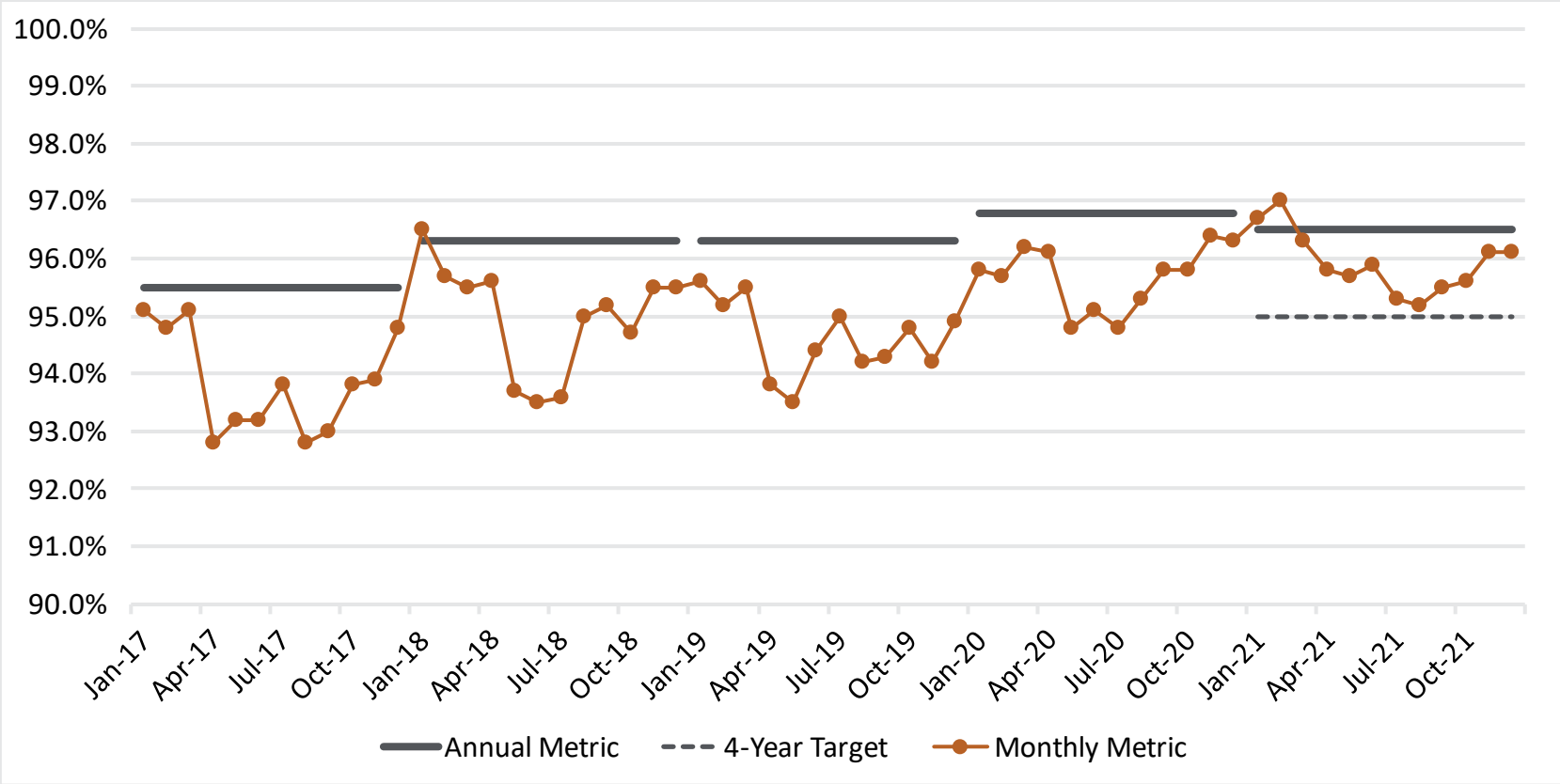
Data source: RITIS MAP-21 tool

Truck Travel Time Reliability Index 2017-2021



Data source: RITIS MAP-21 tool

Non-Interstate NHS
Level of Travel Time Reliability 2017-2021



Data source: RITIS MAP-21 tool

What happened to the Interstate System in 2019?

Flooding in western Iowa

I-29 in March

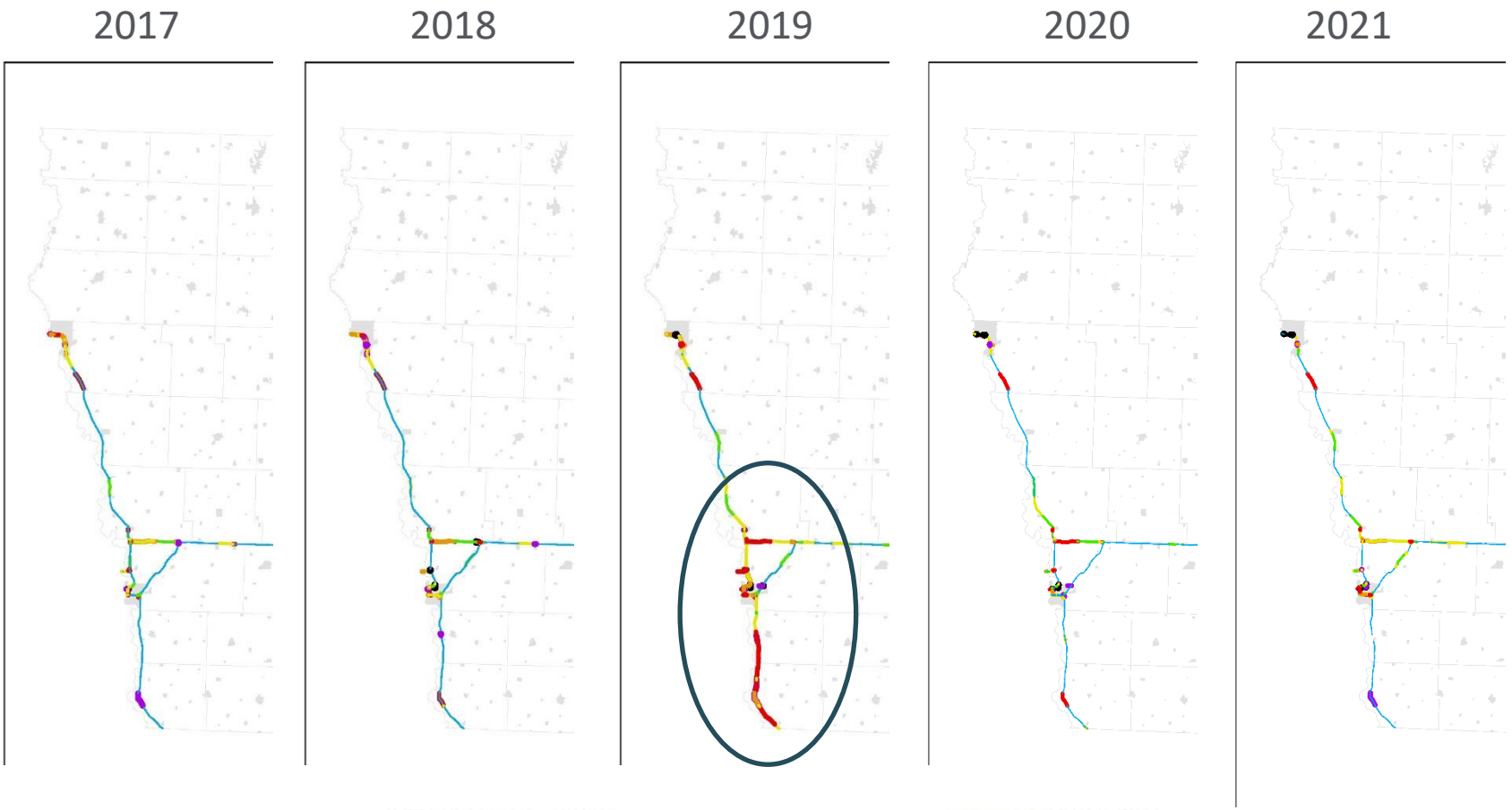
I-29 in June

I-29 in September

Photos: Iowa DOT

- Effects of major natural disaster were reflected in Truck TTR index, but not in Interstate or non-Interstate LOTTR

Truck TTR: I-29



Data source: RITIS MAP-21 tool; NPMRDS shapefile

How much of the system was "unreliable" in 2017-2021?

	2017	2018	2019	2020	2021
	Percent of mileage with reliability metric as defined for that performance measure >= 1.5				
Interstate reliability	0.0%	0.1%	0.3%	0.1%	0.1%
Non-Interstate NHS reliability	3.7%	3.7%	3.9%	4.1%	3.7%
Freight reliability	2.4%	3.6%	5.0%	1.4%	1.8%

I-74 bridge construction in 2021

Source: Iowa DOT

Lessons learned

- Methodology pros and cons
  - Relatively straightforward
  - Data-driven
  - Risk-based
- MAP-21 tool (“easy button”) pros and cons
  - Enables non-technical staff to work with data
  - Available to the state’s MPOs
  - Time, effort, and resources required
  - Customization or ability to drill down into data
  - Data review
- Performance results
  - Show the potential impacts that construction work and natural disasters can have on statewide metrics
  - Of the five years available so far, 2019 was an outlier

Moving forward

- Continue internal review and clean-up of MAP-21 tool data; more in-depth review of performance
- Review other States' methodologies
- Apply lessons learned to future target setting; having such high reliability means that large construction projects or natural disasters can move the needle
- As more data become available, consider transition to trend-based or other methodology
- Continue to explore relationship between PM3 metrics and other data/metrics related to travel time reliability in the planning process
  - Long-range plan operations and bottlenecks analysis and integration into project prioritization
  - Project level efforts

THANK YOU

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VIRGINIA'S TARGET SETTING METHODOLOGY FOR MAP-21 INTERSTATE TRAVEL TIME RELIABILITY MEASURE

NCHRP 23-07 Workshop: Effective Travel Time and Freight Reliability Target Setting Methods

Sanhita Lahiri, VDOT

Simona Babiceanu, VDOT

June 8, 2022

Presentation Outline

- Metric, Measure, and Meaning
- Target Setting
  - Past and Future Data
  - Modeling
  - Prediction
- Questions

MAP-21 Requirement for Interstate Reliability Measure

- **States:**
  - Establish Interstate Travel Time Reliability Measure (PMTR-IS) targets for 2 and 4 years at Statewide and MPO levels
  - If necessary States may adjust target at 2 years

- **FHWA:**
  - Assess whether State achieved or made significant progress toward target every 2 years
  - If not, States have to provide explanations and take remedial actions

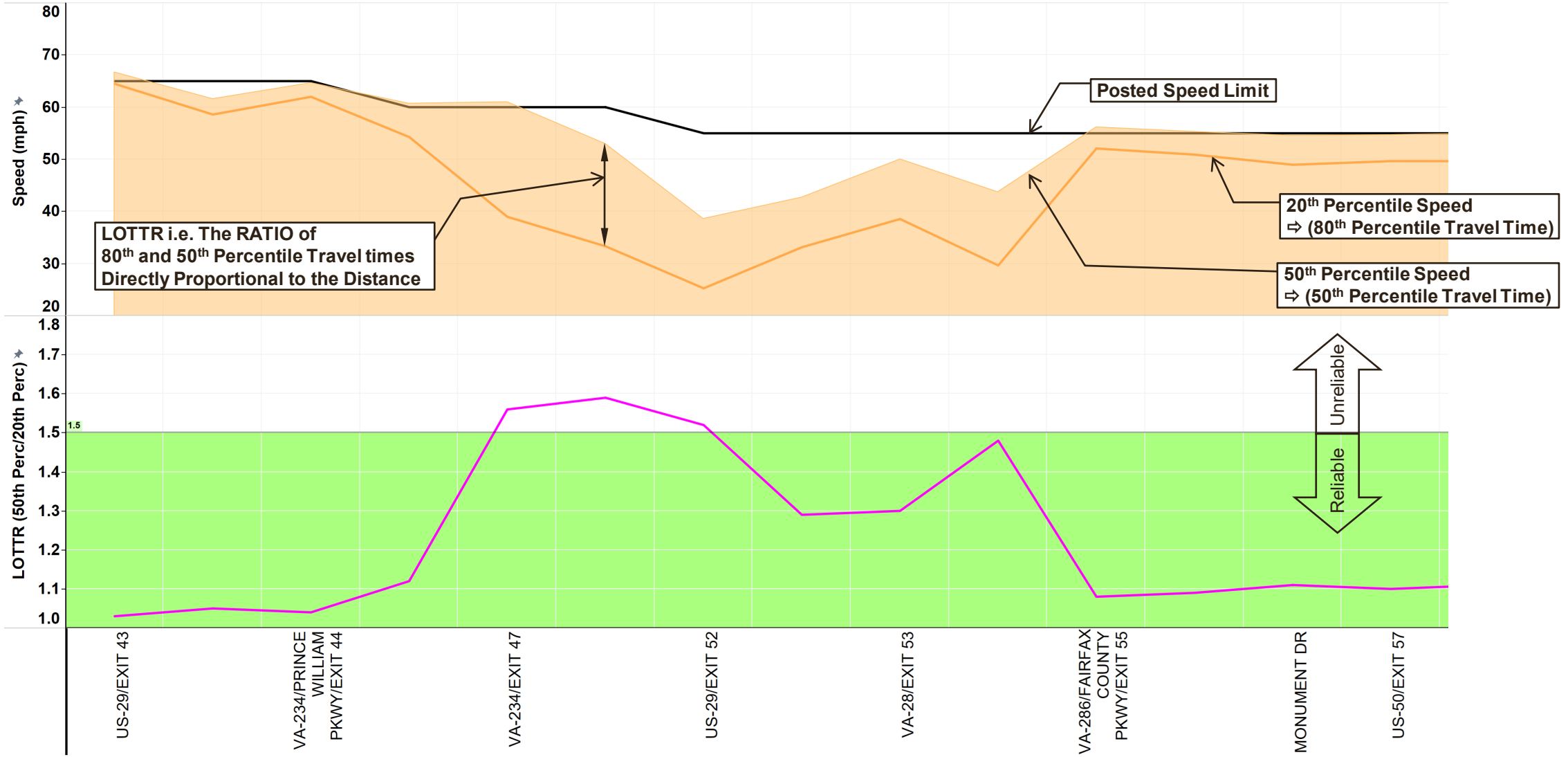
Moving Ahead for Progress in the 21st Century (MAP-21) Law

Travel Time Reliability Metric and Measure

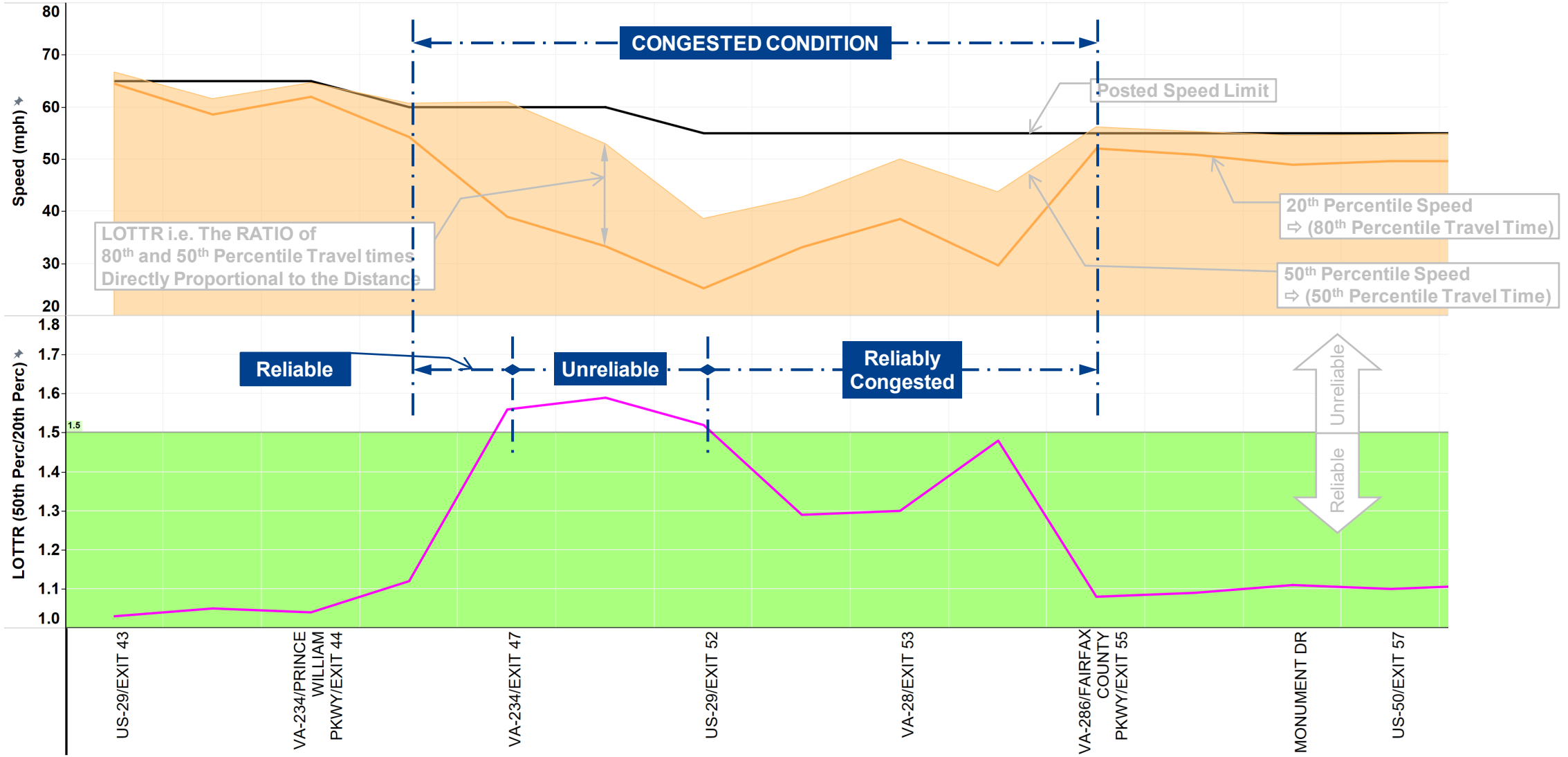
- **Metric: Level of Travel Time Reliability *(LOTTR)***
- **Measure: Percent of Person Miles Traveled on the Interstate that are Reliable or Interstate Travel Time Reliability Measure *(PMTR-IS)***

	Formula	*Example*
Metric **LOTTR**	$\frac{80th\ Percentile\ Travel\ Time}{50th\ Percentile\ Travel\ Time}$ **A segment is Reliable when LOTTR < 1.5 in all 4 time periods****	*LOTTR = 1.50* *You have to add 50% more time to your normal travel time to arrive on-time on 4 out of 5 days*
Measure **PMTR-IS**	$100 \times \frac{Total\ Reliable\ Person\ Miles\ on\ Interstate}{Total\ Person\ Miles\ on\ Interstate}$	*PMTR-IS in Year 2019 = 83.55%* *In Year 2019, 83.55% of the total miles traveled on the Interstate System is Reliable*
**** Time Period**	Weekdays • AM Peak (6a - 10a) • Mid Day Peak (10a - 4p) • PM Peak (4p - 8p) Weekends • Majority hour of Traffic (6a - 8p)	

Example: I-66 EB AM Peak (6 AM – 10 AM)



Example: I-66 EB AM Peak (6 AM – 10 AM)



Target Setting Steps

A. Prepare Input Data for Variables

B. Develop Model for Prediction

C. Validate Model and Predicted **PMTR-IS**

D. Prepare Future Year Data by Predicting variables including running prediction model for crashes

E. Predict Target for **PMTR-IS** for future years

Segment is Reliable when LOTTR < 1.5 for all 4 time periods in one calendar year
PMTR-IS = Interstate Travel Time Reliability Measure

Prepare Input

Interstate Speed and Travel Time – Potential Influencers

Roadway Geometry

- **Segment Length**
- **FHWA Network**
- Number of Lanes
- Terrain

Traffic

- **Annual Average Daily Traffic (AADT)**
- **Occupancy Factor**
- Growth Rate of Daily Vehicle Miles Traveled
- Traffic Volume
- Heavy Vehicle %

Urban Category

- Urbanized
- Urban Cluster
- Rural

Event

- Crashes
- Incidents
- Adverse Weather

Operations Improvement Program

- Safety Service Patrol

Roadway Improvement Types

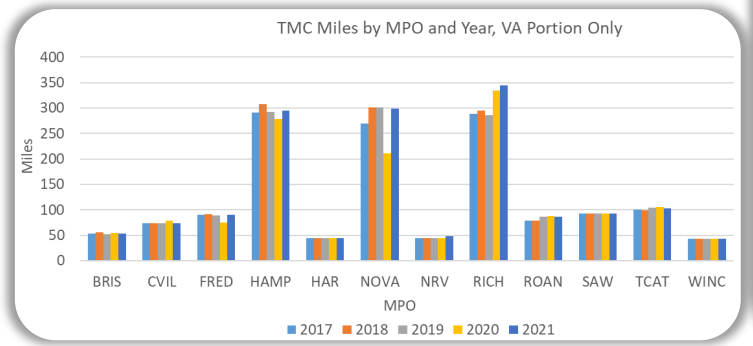
- Capacity Improvement
- Acceleration/ Deceleration Lane Extension

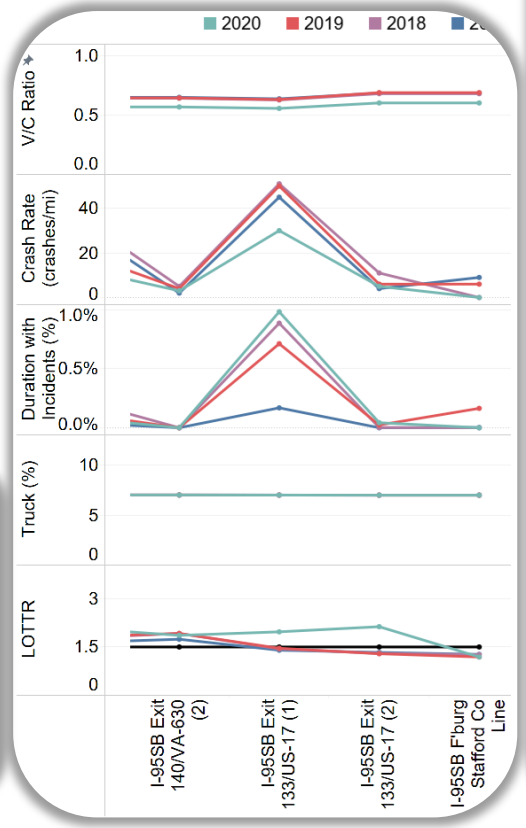
Based on Influencers, Identified 30 Independent Variables

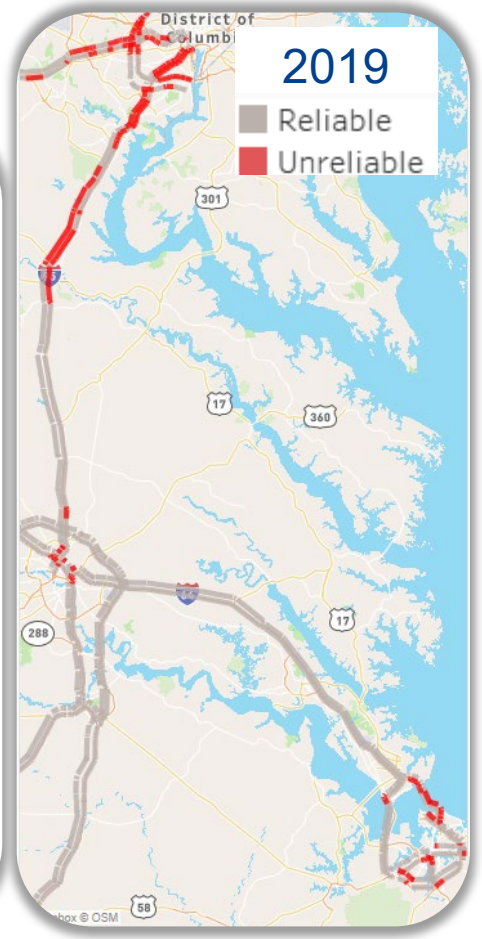
Data Collection, Preparation, and Exploration

> 80 percent of a data scientist's valuable time is spent simply finding, cleansing, and organizing data, leaving only 20 percent to actually perform analysis...
>
> IBM Data Analytics

- Data collected for Travel Time Reliability Influencers
  - Past Years: 2017 to 2021
  - Future Years: 2022 to 2025
- Data Cleaning and Conflation
- Data Exploration and Visualization
- Establish Variables

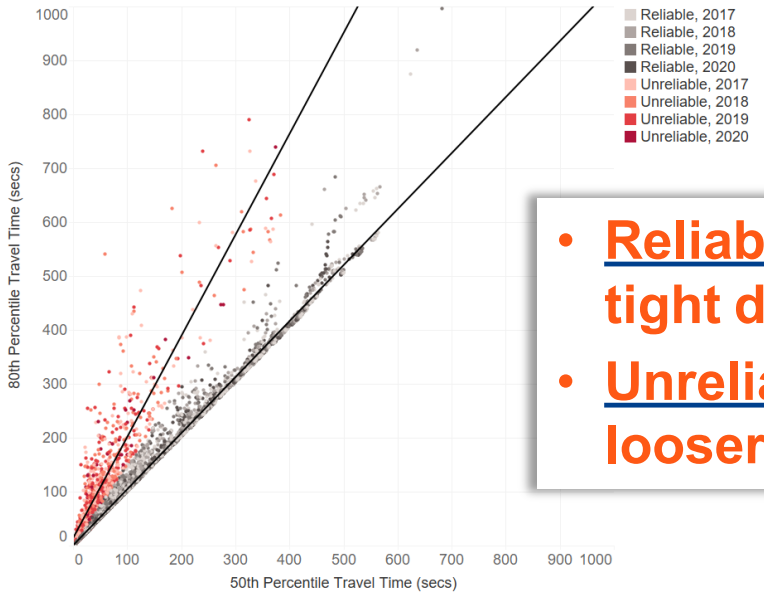




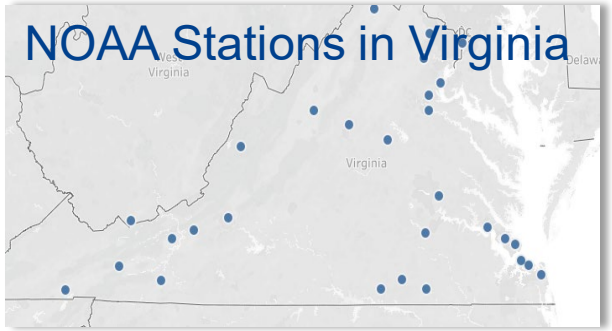


Examples of Issues with available Data

The measure is dependent on the network on which it is calculated, which can have variabilities



- Reliable Segments (Gray) - tight dispersion
- Unreliable Segments (Red) - looser dispersion



Fewer NOAA Weather Stations across the State necessitates extrapolation of Available Data, which can be inaccurate at smaller segment levels

Independent Variables

Data Types	Independent Variables				
Roadway Geometry	Number of Lanes				
	Segment Length				
	Terrain				
Urban Category	Urbanized				
	Urban Cluster				
	Rural				
Independent Variables for each Time period		AMP	MIDD	PMP	WE
Traffic	Volume Capacity Ratio (*v/c*)	✓	✓	✓	✓
	Heavy Vehicle (*%*)	✓	✓	✓	✓
Event	Crashes (*Total Number*)	✓	✓	✓	✓
	Incident Duration (*% time seg. has incident)*	✓	✓	✓	✓
	Adverse Weather from NOAA (*% time seg. has Adverse Weather)*	✓	✓	✓	✓
Ops Imprvmnt Prog	Safety Service Patrol (% of time service available)	✓	✓	✓	✓

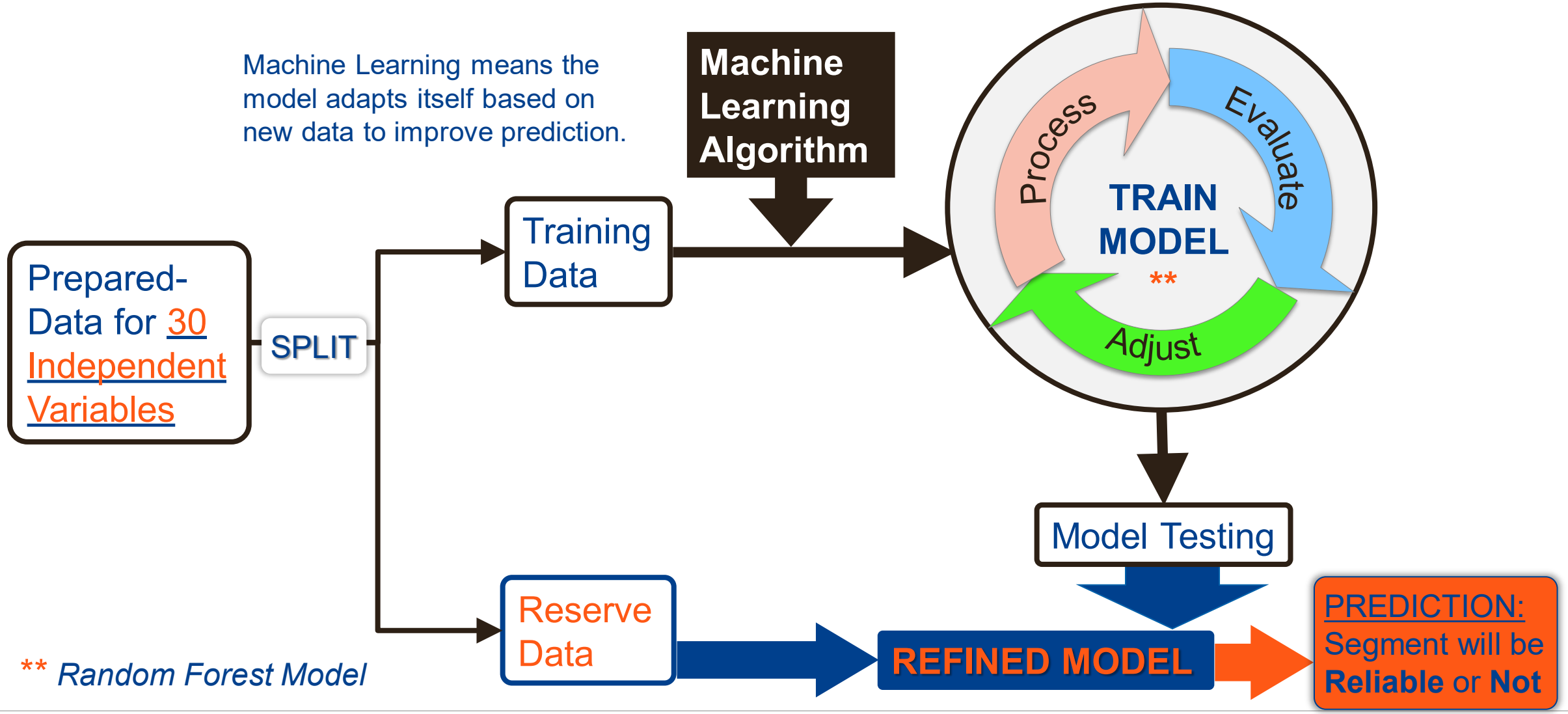
Total Independent Variables Used in the Model = 30

Methodology Exploration

- **Modeling**
  - Simple linear projection (no modeling)
  - Linear Model
  - Classification tree
- **Model Prediction Outputs**
  - LOTTR values
  - 80th & 50th %-ile travel times
  - 20th and 50th %-ile speeds
- **Model Inputs**
  - Separate data into reliable and unreliable sets
  - Eliminate Weekend data
  - Eliminate short segments (< 0.1 mi)
  - Treat crashes and incidents as rates per mile
  - Hourly volumes instead of V/C ratios

Random Forest model

Machine Learning means the model adapts itself based on new data to improve prediction.

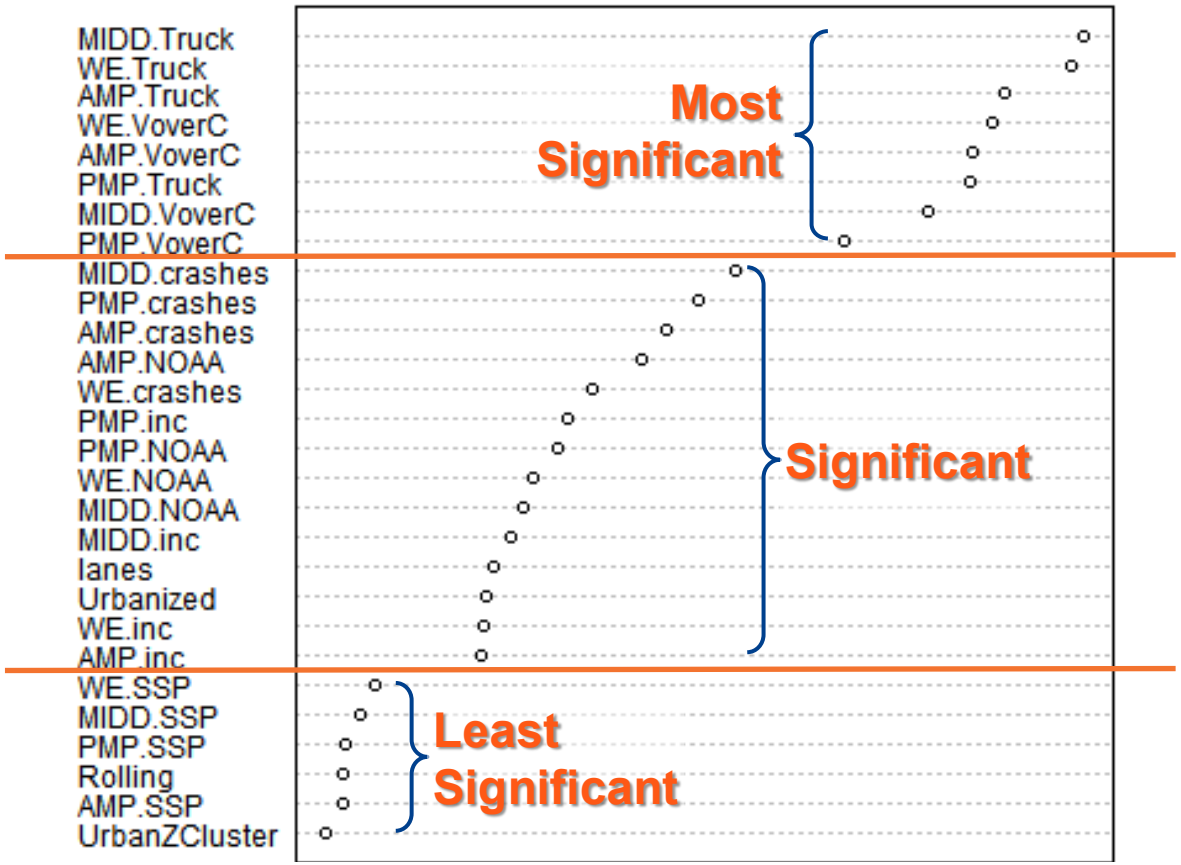


** *Random Forest Model*

Insight from Model Run

Significance of Independent Variables influencing Reliability:

- The higher on the Y-axis, the more important the variable
- 3 logical groups
  - Most significant: V/C and truck percentage
  - Significant: events, number of lanes
  - Least significant: Safety Service Patrol, terrain, urban cluster



Model Validation

Step 1 of two-step validation process

Year	Testing Data Set Membership				Correct Predictions of Testing Data Set		
	Obs Rel Pred Rel	Obs Rel Pred Unrel	Obs Unrel Pred Rel	Obs Unrel Pred Unrel	Accuracy (All Segments)	Sensitivity (Reliable Segments)	Specificity (Unreliable Segments)
2017	470	14	23	52	93.38%	97.11%	69.33%
2018	462	13	22	54	93.65%	97.26%	71.05%
2019	489	17	20	61	93.70%	96.64%	75.31%
2020	520	4	13	10	96.89%	99.24%	43.48%
2021	508	13	24	32	93.59%	97.50%	57.14%
All	2450	61	103	209	94.19%	97.57%	66.99%

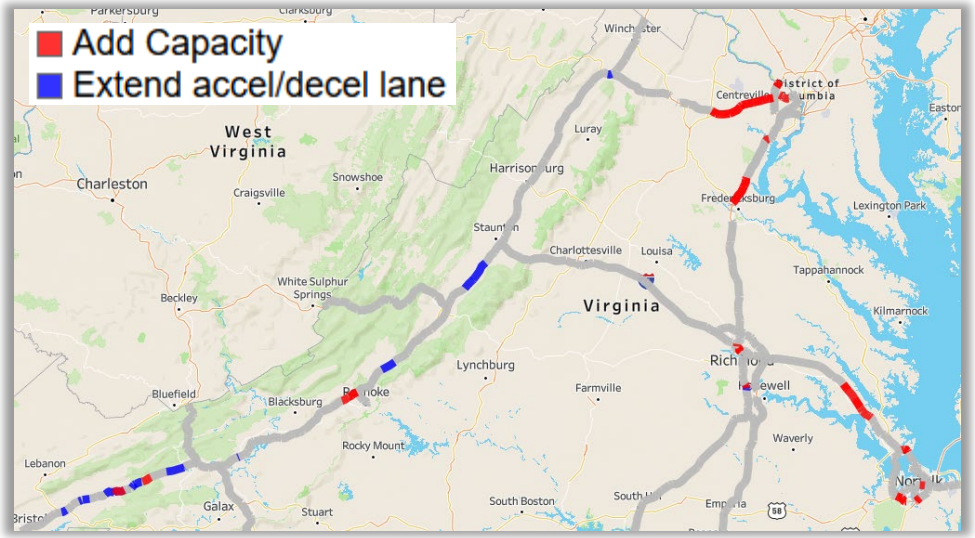
Measure Validation

Step 2 of two-step validation process

Year	Predicted PMTR-IS	Actual PMTR-IS	Error
2017	82.71%	82.48%	0.28%
2018	82.87%	82.62%	0.30%
2019	83.30%	83.55%	-0.30%
2020	94.19%	93.80%	0.42%
2021	86.28%	86.25%	0.04%

Prepare Future Year Data

- **Six Year Improvement Program Projects - Completion between 2022 and 2025**
  - **Add Capacity**
  - **Extend acceleration /deceleration lanes**



Project Type	2022 miles	2023 miles	2024 miles	2025 miles
Add Capacity	48.96	78.34	135.7	142.36
Extend accel/decel lane	27.29	45.9	47.4	47.44
Total	76.25	124.25	183.14	189.8

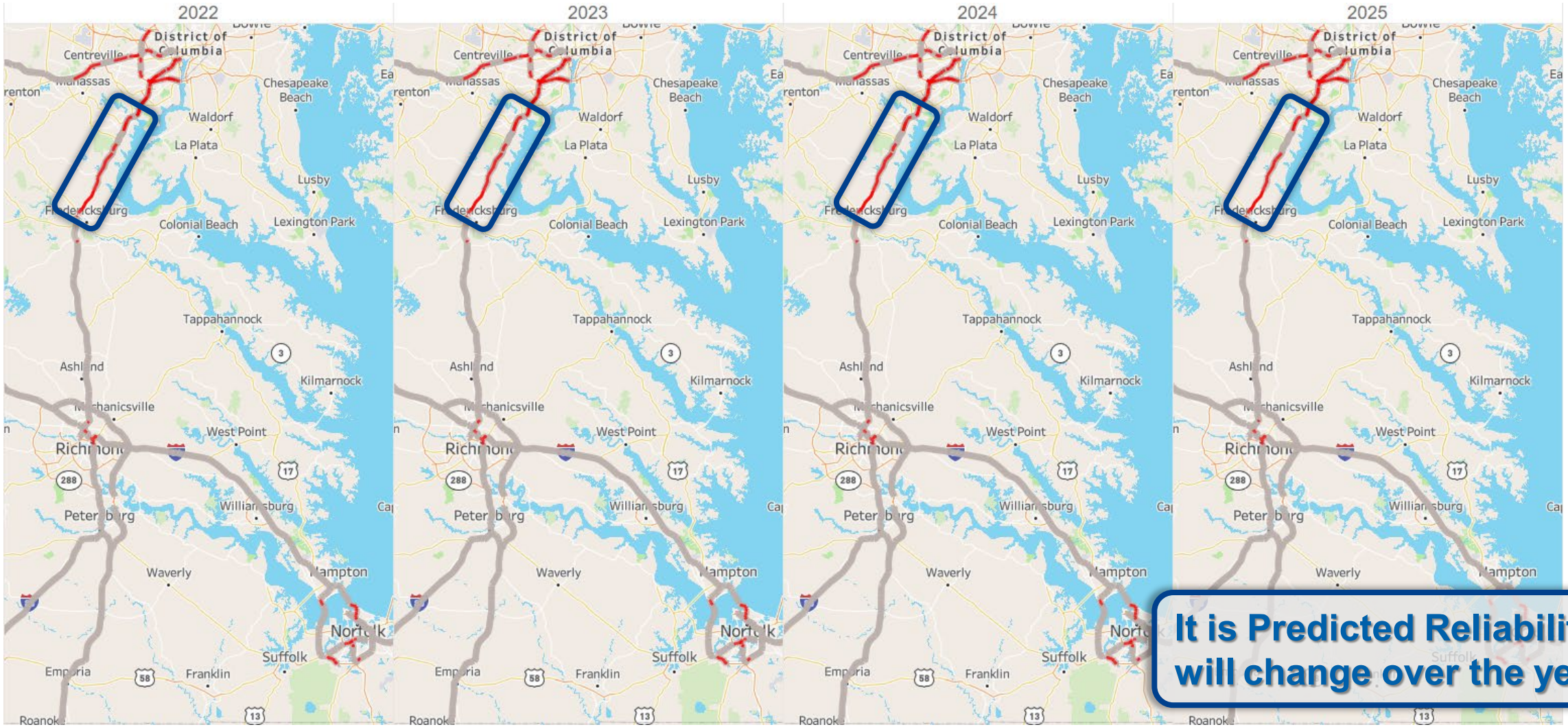
Prepare Future Year Data

- **Crashes**
  - **Predict Future year total crashes by segment using SPF (Safety Performance Function) model developed by VDOT's Safety group**
    - Model = power function by site type using segment length and estimated future AADT
    - Site types characterized by number of lanes, urban/rural, internal/external
    - Predict total daily crashes, calibrate, apply crash fraction by period

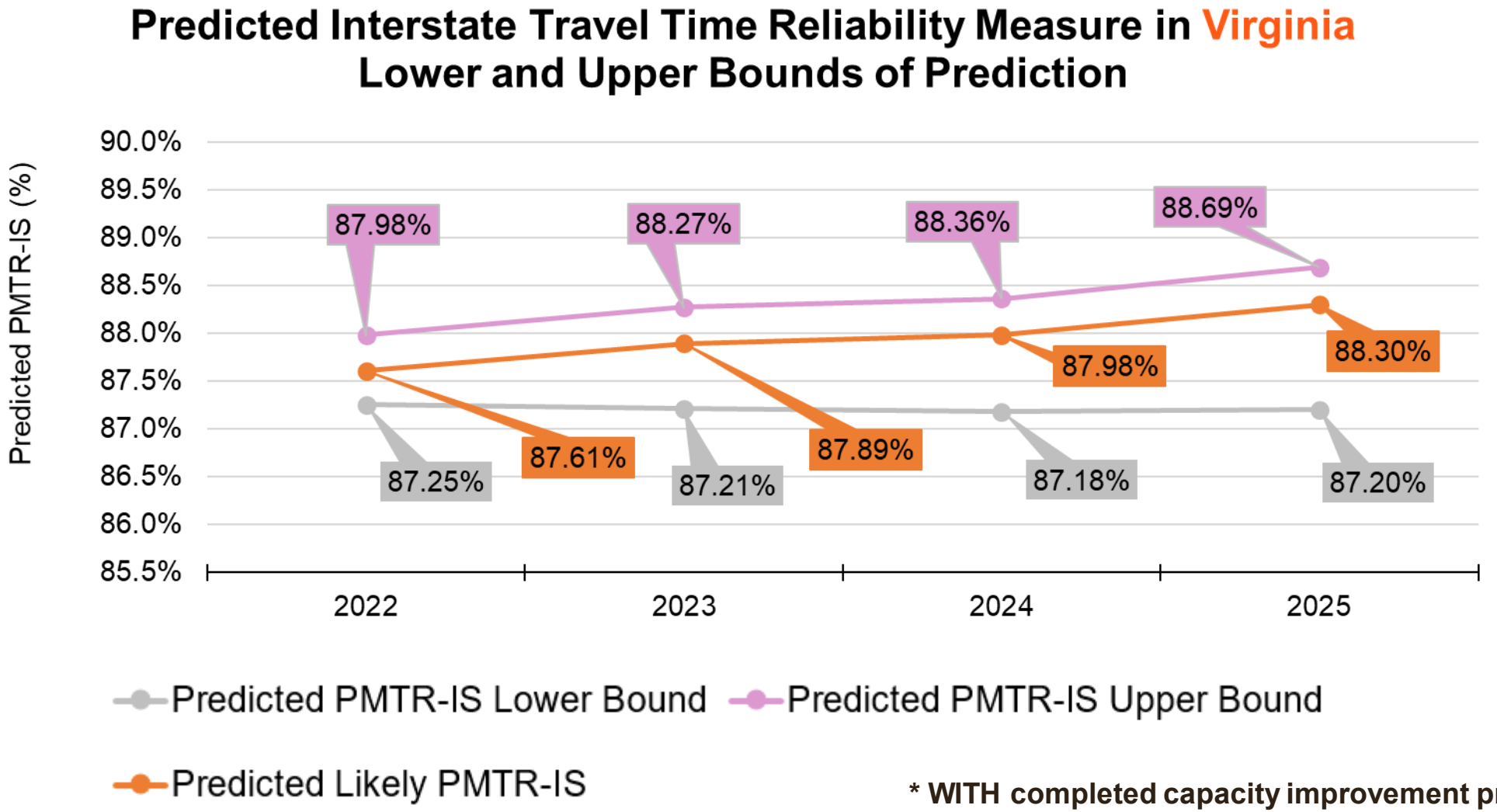
Prepare Future Year Data

- **Volume to Capacity Ratio**
  - AADT based on most recent year and VMT growth factors
  - Use future year number of lanes based on projects
- **Other influencers**
  - Weather, Incidents – average of historical
  - SSP, Terrain, Urban category – constant, latest available values

Virginia Predicted Segment Reliability 2022-2025



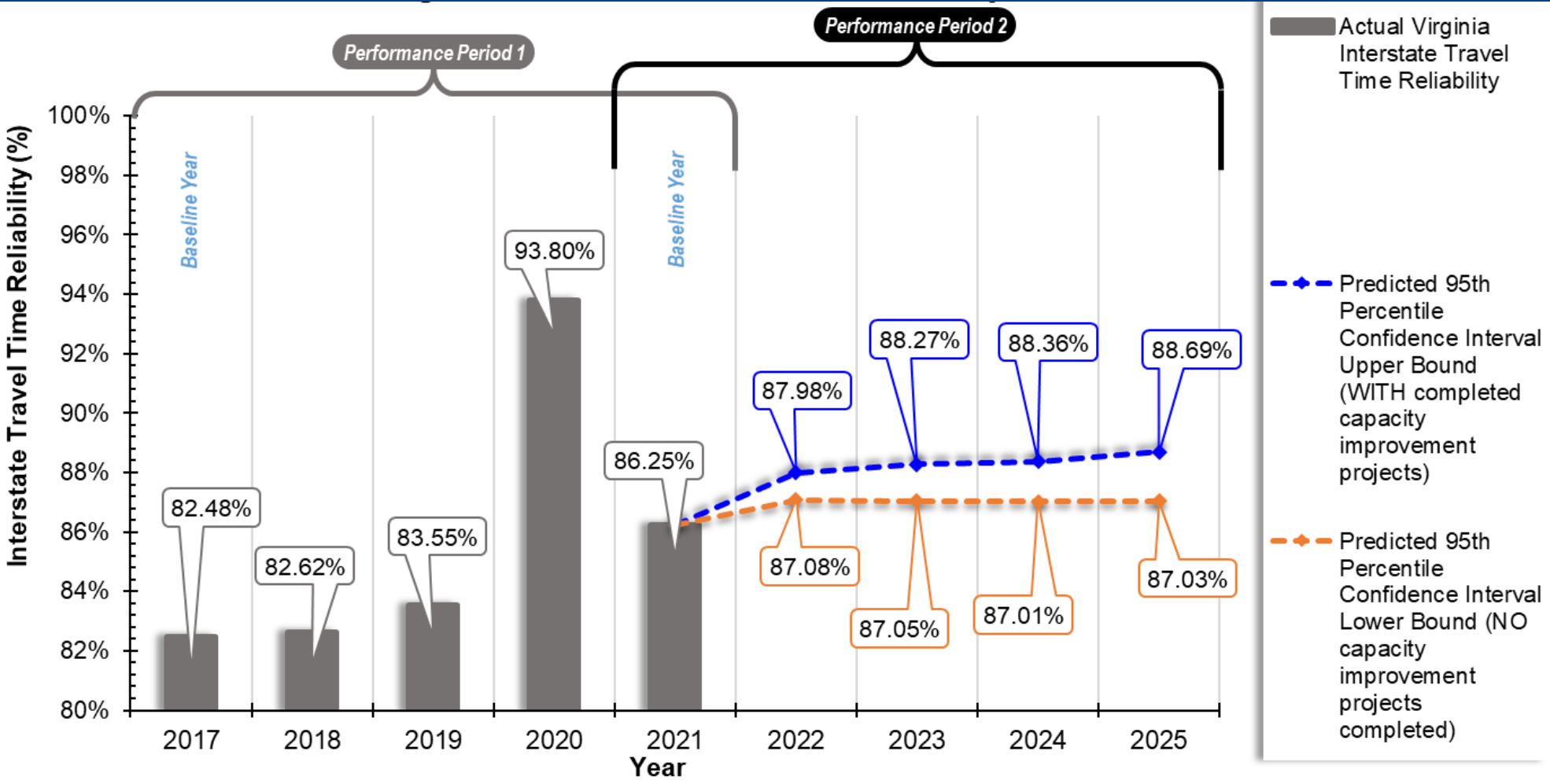
PMTR-IS Prediction – Statewide



*** WITH completed capacity improvement projects**

Predict Target

Predicted Virginia Interstate Travel Time Reliability Measure



Predict Target

Predicted Interstate Travel Time Reliability Measure by MPO

MPO	2022		2023		2024		2025	
	95th % CI Lower Bound No Project	95th % CI Upper Bound Project	95th % CI Lower Bound No Project	95th % CI Upper Bound Project	95th % CI Lower Bound No Project	95th % CI Upper Bound Project	95th % CI Lower Bound No Project	95th % CI Upper Bound Project
FRED	67.57%	75.08%	67.19%	80.55%	67.10%	79.84%	67.09%	79.51%
HAMP	94.98%	95.95%	94.87%	95.86%	94.87%	95.77%	94.80%	95.58%
NOVA	65.12%	66.58%	65.07%	66.47%	64.96%	67.05%	64.99%	68.30%
RICH	96.97%	97.41%	96.98%	97.37%	97.04%	97.33%	97.21%	97.48%
BRIS, CVIL, HAR, NRV, ROAN, SAW, TCAT, and WINC	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Target Setting Methodology for Percent of Person Miles Traveled on the Interstate that are Reliable – Summary

- Random Forest Machine Learning Algorithm can be used
- The independent variables can be influenced by factors not in our control that can have impact on the predicted number e.g.:
  - Unexpected change in Growth due to Land Use change
  - Redefining of Urban Category based on Census results
  - Change in Travel Pattern due to Pandemic Impact
  - Other unexpected shifts…
- Target Setting: It is recommended to consider a short range of oscillation for prediction

Model Use

- The Model created with the Machine Learning technique, and using 30 independent variables produces results that are close to actual Interstate Travel Time Reliability
- The model shows sensitivity to local changes in network
  - The Model can be used at MPO level for setting MAP-21 Targets, however verification and MPO input is necessary
  - Potential impact of other variables can be tested including impact of long term Work Zones (if any)

Reliability Performance Measures for Virginia

Virginia needs appropriate Reliability Measures to:

- Compare Improvement Alternatives
- Capture Benefits of Traffic Management
- Be sensitive to Investment Strategies
- Assess System Performance in Virginia

Reliability Performance Measures for Virginia

Why not MAP-21 Travel Time Reliability Measure for Virginia?

- Large Time Periods (4/6/10 hrs) mask hourly Reliability fluctuations
- One calendar year span masks seasonal variations
- Limited Geographical Scale (Statewide and MPO)
- LOTTR metric is NOT always appropriate for use because of Virginia's unique:
  - Congestion characteristics, and
  - Improvement projects

Reliability Performance Measures for Virginia

How MAP-21 Travel Time Reliability Measure Reporting and Target Setting helped Virginia?

- Aided in institutionalizing Reliability as a required Performance Measure in Virginia
- Help move the story from managing congestion to managing reliability
- Setting Targets help in accountability and achieving goals

Use Prepared Data and Model for Virginia Specific Measures:

- Test potential metrics and thresholds
- Test sensitivity of proposed Measures

Acknowledgments

- Mena Lockwood
- Margie Ray
- Katie Felton
- Allan Yue
- Michael Fontaine
- Ramkumar Venkatanarayana

Questions?

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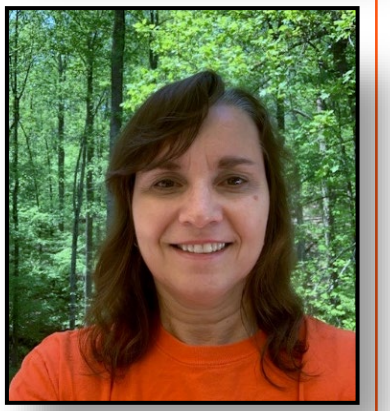

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Discussion

- What challenges or benefits have you found with your method of target setting?
- Do you or your agency wish to use a different method but face a barrier?
- Have you been able to leverage the target setting or performance review process to bring about new actions to address performance?
- What elements have made the process more effective/ meaningful?
- Have agencies set increasing (worsening) targets and still missed them?
- How have you successfully communicated your targets to your MPOs? Leadership? The public?