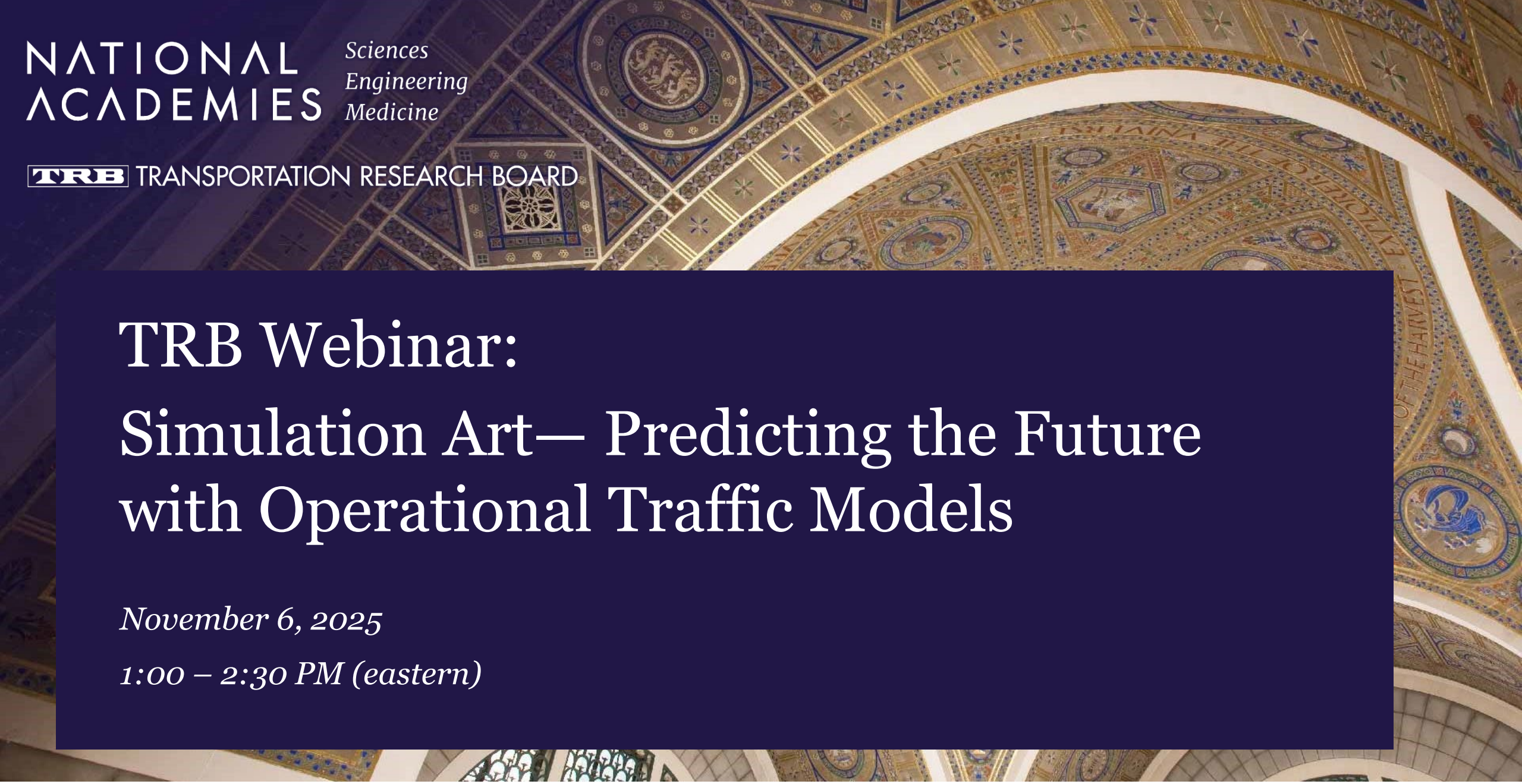


NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar:

Simulation Art— Predicting the Future with Operational Traffic Models

November 6, 2025

1:00 – 2:30 PM (eastern)

PDH Certification Information

1 Professional Development Hour (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

ENGINEERING RCEP
REGISTERED CONTINUING EDUCATION PROGRAM

NATIONAL ACADEMIES Sciences Engineering Medicine
TRB TRANSPORTATION RESEARCH BOARD

Purpose Statement

This webinar will explore how DOTs use operational traffic simulation models in practice. Presenters will share examples of how simulation modeling supports real-world transportation projects, and discuss lessons learned from Virginia's policies and practices for traffic operations analysis.

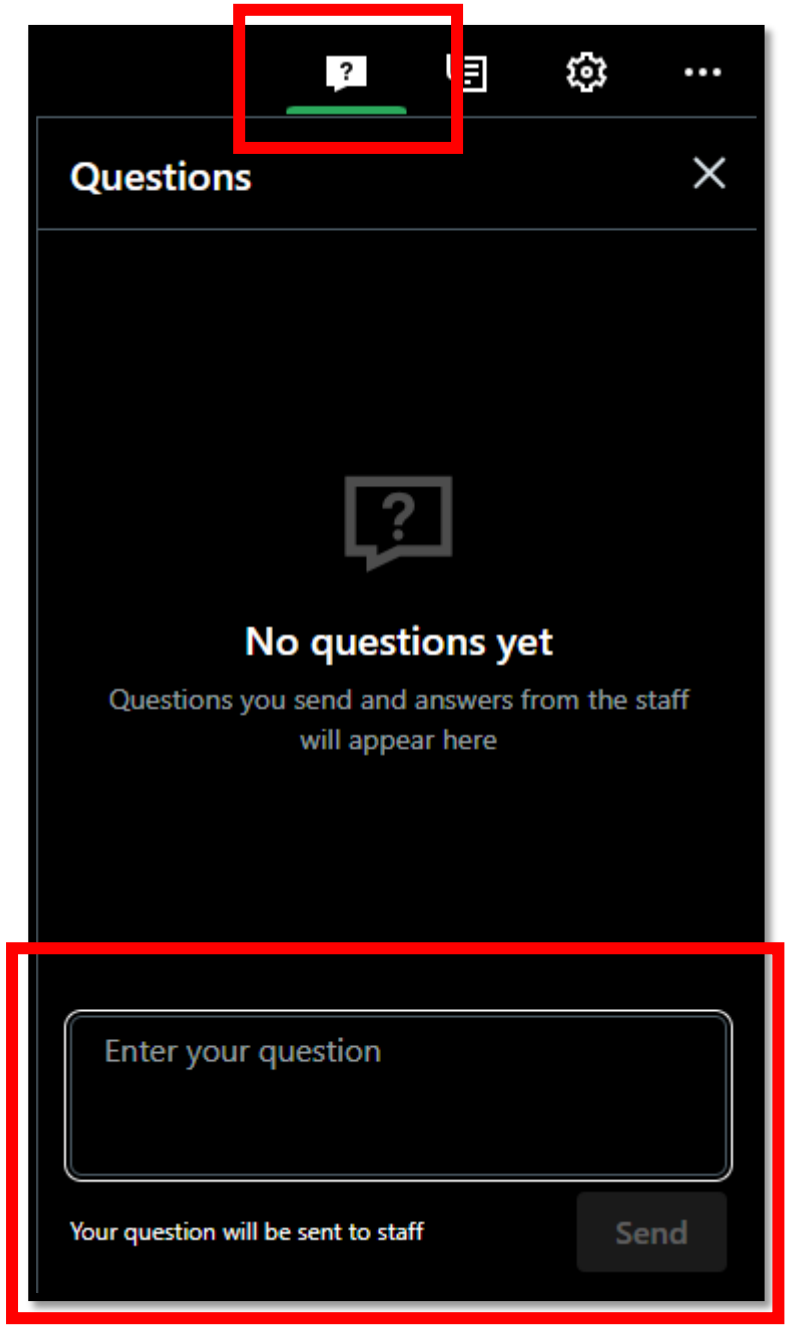
Learning Objectives

At the end of this webinar, participants will be able to:

- Describe general DOT practices for operational traffic simulation models,
- Identify applications of operational traffic simulation models and conditions that are most suitable for the use of operational traffic simulation models, and
- Consider tradeoffs between precision and data availability and other constraints in the use of operational traffic simulation models.

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's Presenters

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VDOT Virginia Department of Transportation

NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

Simulation Art – Predicting the Future with Operational Traffic Models

Policies and Practices for Traffic Operations Analysis in Virginia

Sanhita Lahiri, P.E., PTOE
Central Office, Traffic Operations Division

November 6, 2025

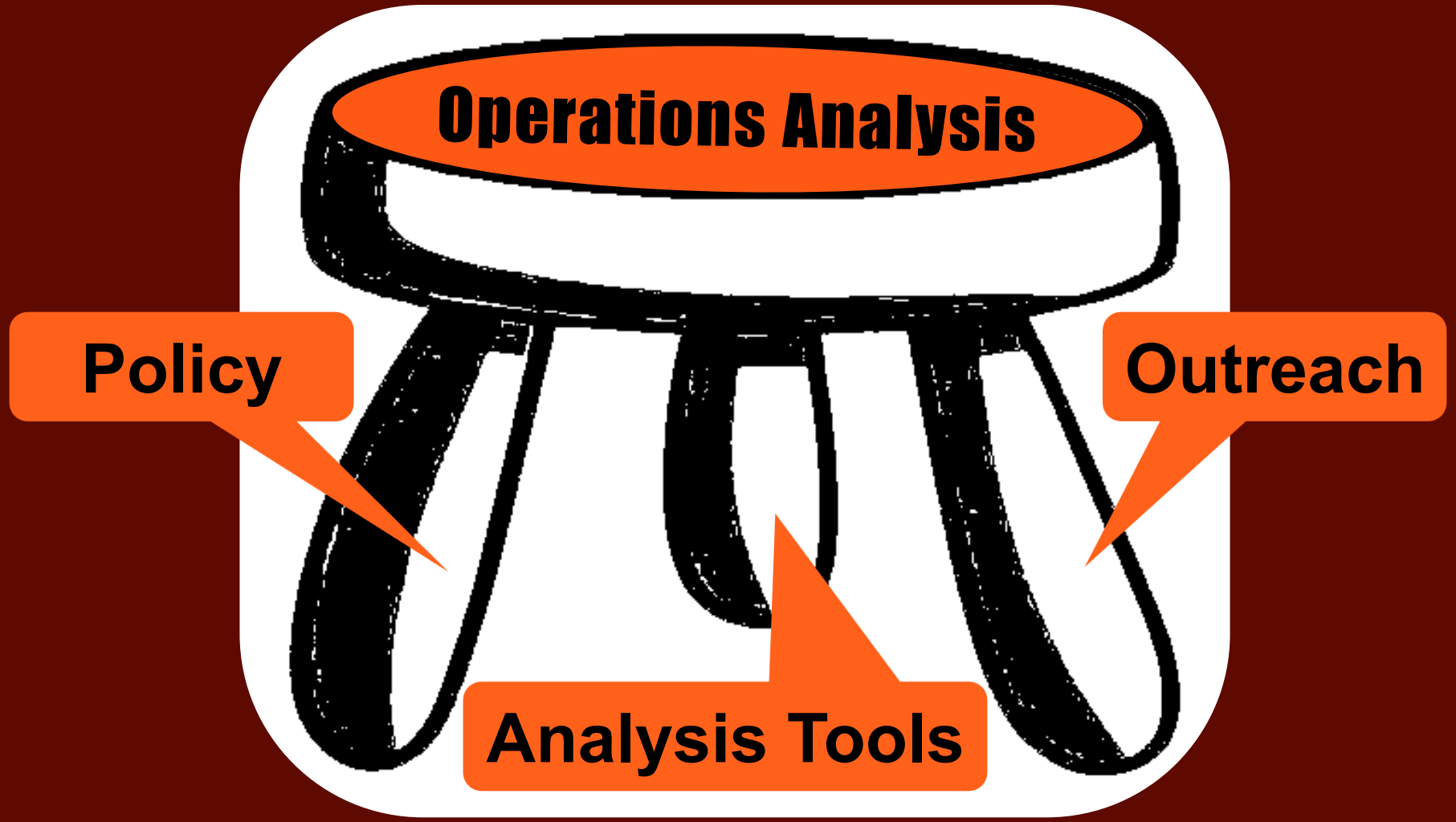
Operations Analytics Guidance Based on Context

- **Improvement Needs**
  - Safety, Mobility, Access Management
- **Impact Analysis**
- **Before / After Improvement Comparison**
- **Monitoring**
- **Phase of Capital Improvement Project and level of analysis needed**
  - Screening, Visioning, Operations, Design
- **Modeling Approach**
  - Traffic Engineering Models – Deterministic, Mesoscopic, Microscopic
  - Machine Learning Models – Corridors with Big Data and/or Heterogenous Data

Engineering Judgment must be exercised.

Comprehensive Approach

GUIDANCE

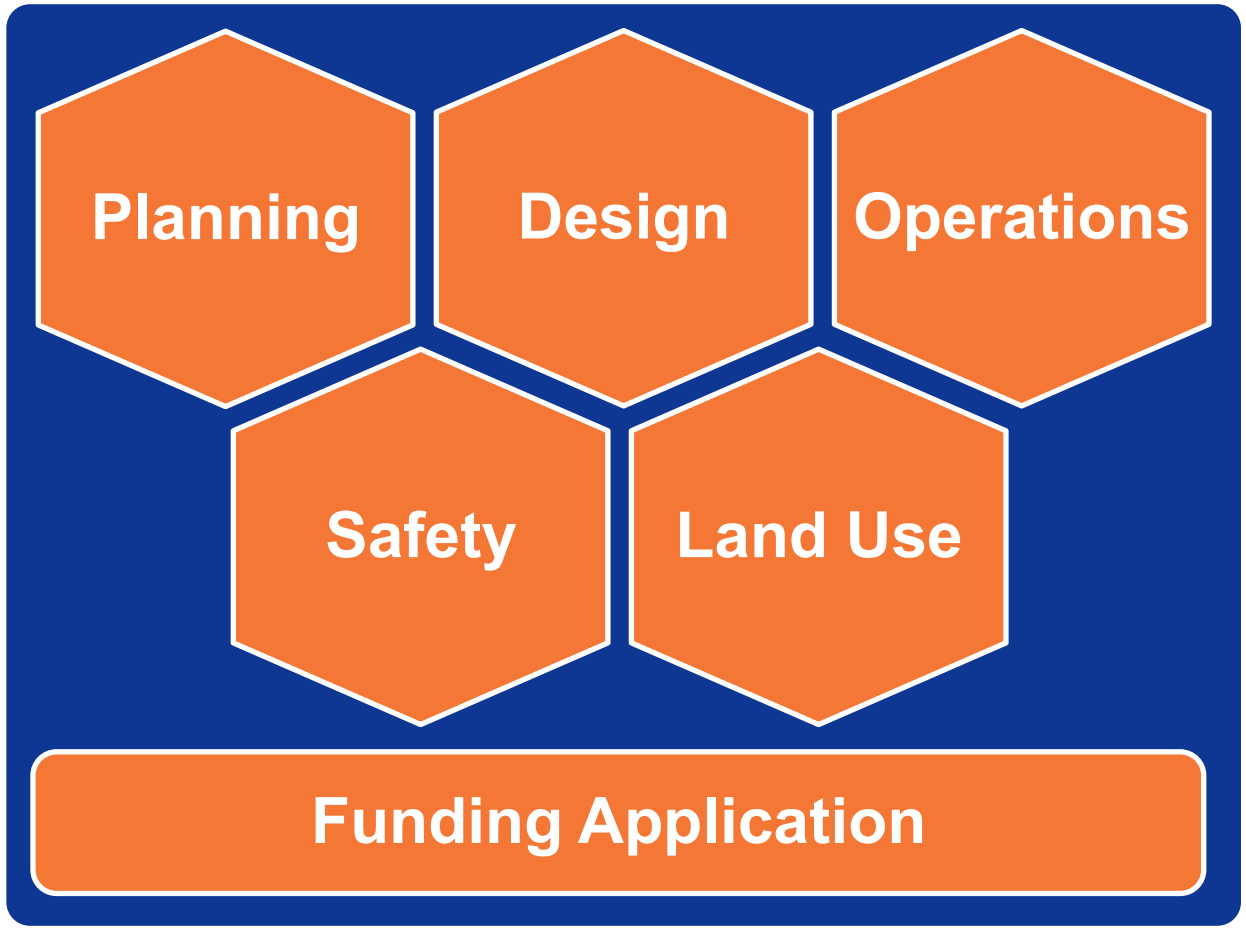


Comprehensive Approach

STARS

PROJECT PIPELINE

SMART SCALE
Funding the Right Transportation Projects in Virginia



Holistic Contextual Guidance – In Manuals

- Traffic Operations and Safety Analysis Manual (TOSAM)
- VDOT Road Design Manual:
  - VDOT Road Design Manual, Appendix A: Innovative Intersection/ Interchange Design Guidelines
  - Appendix F: Access Management Design Standards for Entrances and Intersections
- Administrative Guidelines for Traffic Impact Analysis Regulations
- Technical Guide for SMART Scale Funding Application

New Roundabout Guidance based on NCHRP 1043 incorporated in 2024

Cyan Highlights Under Revision!

Holistic Contextual Guidance – VDOT Processes & Tools

VDOT has adopted principles from the FHWA ICE framework and a **Safe Systems Approach** to establish the Virginia Intersection and Interchange Control Assessment Program (Virginia iCAP)

Virginia iCAP Process

APPLICABILITY	ASSESSMENT STAGE 1	ASSESSMENT STAGE 2
Is The Process Required?	**Screening To Establish A List Of Viable Intersection Types**	**Evaluate Alternatives To Narrow Selection**
• Project Location • Project Purpose and Need (PPN) • Performance Based Practical Design	• Congestion (v/c) • Safety (Conflict Points) • Ped/Bike (Accommodation) • Cost (Planning Level)	• Traffic Operations (MOEs based on PPN) • Safety (Crash and Crash Reduction) • Cost (Environmental, Right of Way, Construction) • Optimal Benefit

BEST PRACTICE

VJuST ***VDOT Junction Screening Tool***

iCAP ***Virginia iCAP Assessment Tool***

Cyan Highlights Under Revision!

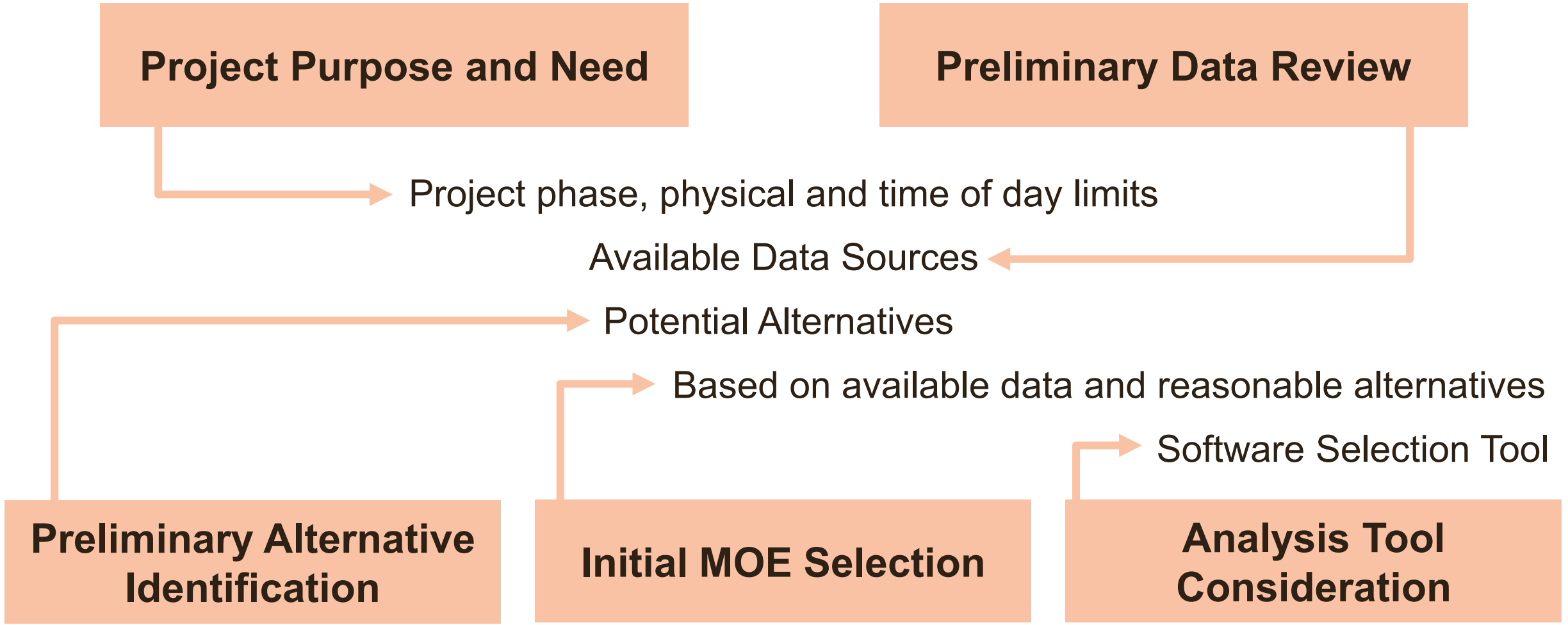
VDOT Instructional & Informational Memorandums (IIM)*

- Virginia Intersection and Interchange Control Assessment Program (iCAP) Policy and Guidance *(IIM-TOD-397)*
- Signal Justification Reports (SJRs) For New and Reconstructed Signals *(IIM-TE-387.1)* ***to be Revised to IIM-TOD-401***
- Innovative Intersection/ Interchange Committee *(IIM-TE-389)*
- Process for Designating Arterial Preservation Network (APN) Corridors and Conducting Planning Studies on the Network *(IIM-TMPD-2.1)*
- Strategically Targeted Affordable Roadway Solutions (STARS) Program *(IIM-TMPD-3.1)*
- Development of Justification for Additional or Revised Access Points; Creation of Interchange Access Reports (IAR) and Operational and Safety Analysis Reports (OSAR) *(IIM-LD-200.11)*
- Review of site plans and subdivision plat *(IIM-LU-500.3)*
- Access Management Spacing Exceptions/Waivers *(IIM-LU-501.3)*

Cyan Highlights Under Revision!

* Instructional & Informational Memorandum (IIM) – Serves as VDOT Policy

Scoping

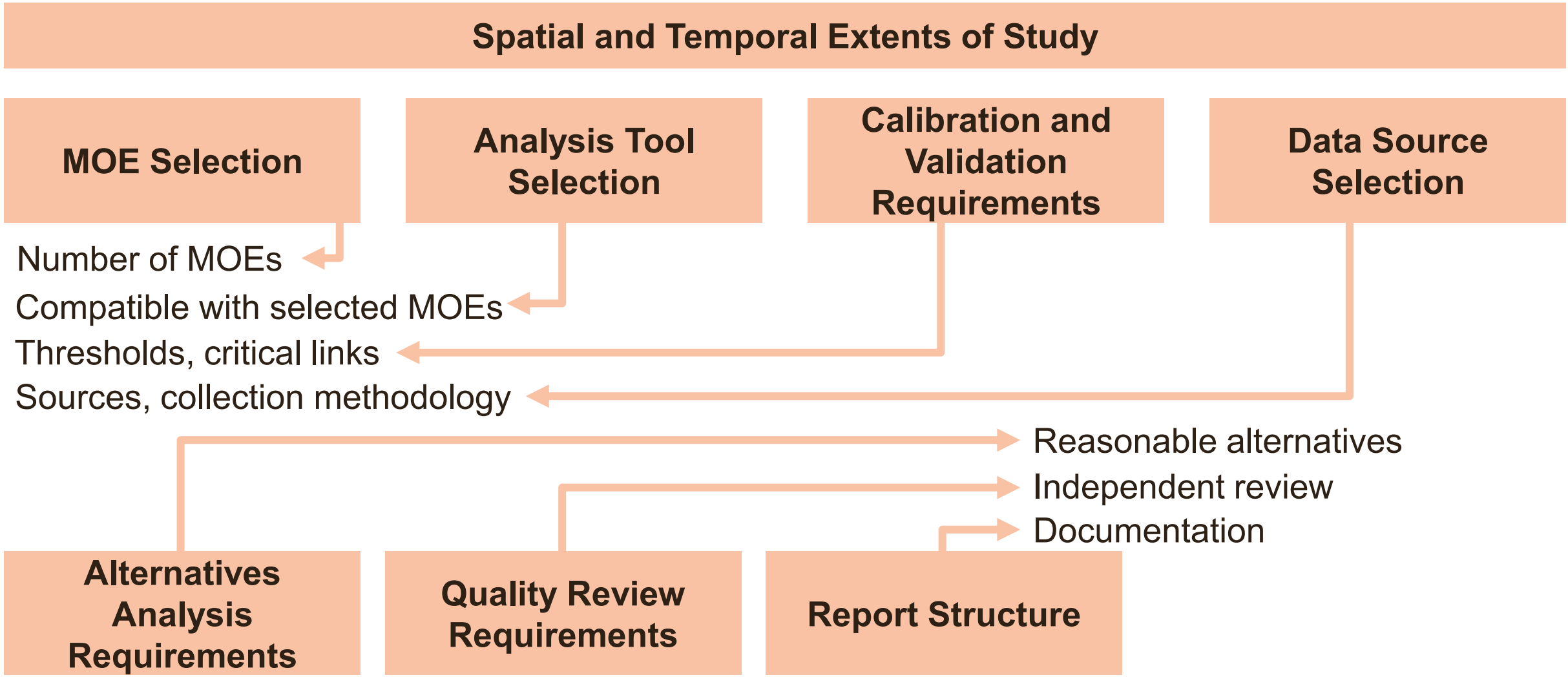

Project Purpose and Need
Preliminary Data Review
Project phase, physical and time of day limits
Available Data Sources
Potential Alternatives
Based on available data and reasonable alternatives
Software Selection Tool
Preliminary Alternative Identification
Initial MOE Selection
Analysis Tool Consideration

Scoping – Spatial and Temporal Study Limits

Influencing Factors:

- Queue formation and dissipation
- Existing travel patterns and future traffic growth
- Adjacent facilities
- Future Land Use and Demand
- Pedestrian and Bike Mobility
- NEPA compliance
- Review Relevant Data to gain a preliminary understanding of Saturation
  - Historical traffic counts
  - K-factors, D-factors, Truck percentages
  - Traffic forecasting data (e.g., historical growth rates, travel demand model)

Scoping Agreement



Project Phase Based Analysis

	Objective	Horizon Year	Cost Estimate	Alternatives Inputs	Alternatives Outputs
Screening	Determine the suitability of project alternatives	All timeframes	Planning Level	Many	Several
Visioning Level	Refine project alternatives	10 to 20 Years	Planning Level	Several	Few
Program Level	Select a preferred alternative to be shared with stakeholders	10 to 20 Years	Project Level	Few	One or Two
Operations Level	Determine roadway, signal, and safety impacts	< 10 Years	Project Level	Few	One or Two
Design Level	Model traffic impacts to inform design decisions	< 5 Years	Project Level	Few	One or Two

Screening Phase

Objective: Determine the suitability of project alternatives

Horizon Year: All timeframes **Cost Estimating Level:** Planning-level

Alternatives Analysis Inputs: Many **Alternatives Analysis Outputs:** Several

Approval: VDOT Project Manager or Designee

Traffic Tools		Safety Tools	
VJuST	Intersection, Corridor	HSM Spreadsheets	Intersection, Corridor
HCS	Intersection, Corridor, Network	ISATe	Corridor
SIDRA	Intersection	IHSDM	Intersection, Corridor, Network
Synchro	Intersection, Corridor, Network		
FREEVAL	Intersection, Corridor		

Legend

- Intersection
- Corridor
- Network

Project Planning Phase – Visioning Level

Objective: Refine project alternatives

Horizon Year: 10-20 years **Cost Estimating Level:** Planning-level

Alternatives Analysis Inputs: Several **Alternatives Analysis Outputs:** Few

Approval: VDOT Project Manager or Designee

Traffic Tools		Safety Tools	
VJuST	● ●	HSM Spreadsheets	● ●
HCS	● ● ●	ISATe	●
SIDRA	●	IHSDM	● ● ●
Synchro	● ● ●		
FREEVAL	● ●		

Legend

- ● Intersection
- ● Corridor
- ● Network

Project Planning Phase – Program Level

Objective: Select a preferred alternative to be shared with stakeholders

Horizon Year: 10-20 years **Cost Estimating Level:** Project-level

Alternatives Analysis Inputs: Few **Alternatives Analysis Outputs:** One or two

Approval: VDOT Project Manager, DTE, or Designee

Traffic Tools		Safety Tools	
HCS	● ● ●	HSM Spreadsheets	● ●
SIDRA	●	ISATe	●
Synchro, SimTraffic	● ● ●	IHSDM	● ● ●
FREEVAL	●		
Vissim	● ● ●		

Legend

- Intersection
- Corridor
- Network

Project Implementation Phase – Operations Level

Objective: Determine roadway, signal, and safety impacts

Horizon Year: Less than 10 years **Cost Estimating Level:** Project-level

Alternatives Analysis Inputs: Few **Alternatives Analysis Outputs:** One or two

Approval: VDOT Project Manager, DTE, or Designee

Traffic Tools		Safety Tools	
HCS	Intersection, Corridor, Network	HSM Spreadsheets	Intersection, Corridor
SIDRA	Intersection	ISATe	Corridor
Synchro, SimTraffic	Intersection, Corridor, Network	IHSDM	Intersection, Corridor, Network
FREEVAL	Corridor		
Vissim	Intersection, Corridor, Network		
VDOT Work Zone Tool	Corridor		

Legend

- Intersection
- Corridor
- Network

Project Implementation Phase – Design Level

Objective: Model traffic impacts to inform design decisions

Horizon Year: Less than 5 years **Cost Estimating Level:** Project-level

Alternatives Analysis Inputs: Few **Alternatives Analysis Outputs:** One or two

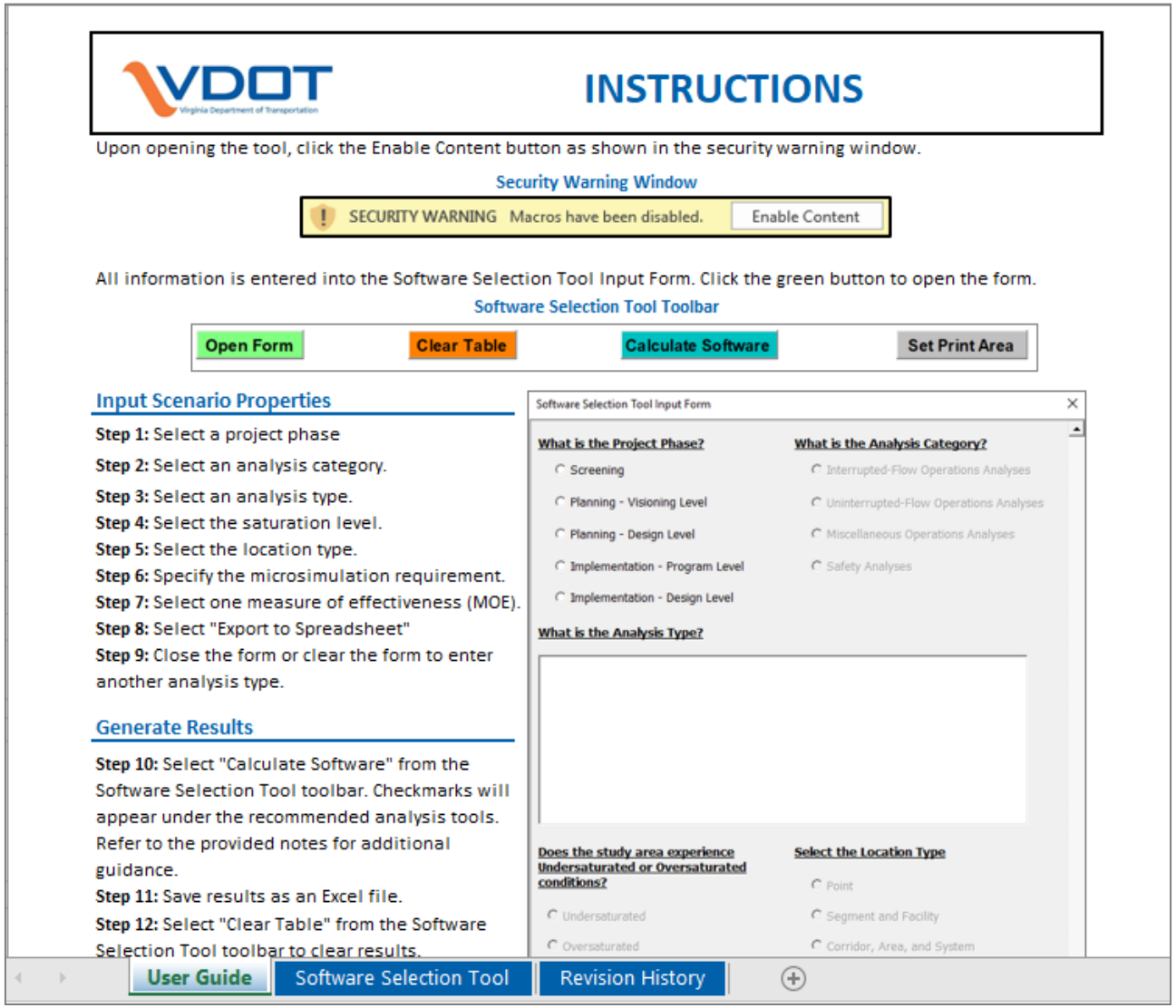
Approval: VDOT Project Manager, DTE, or Designee

Traffic Tools		Safety Tools	
HCS	Intersection, Corridor, Network	HSM Spreadsheets	Intersection, Corridor
SIDRA	Intersection	ISATe	Corridor
Synchro, SimTraffic	Intersection, Corridor, Network	IHSDM	Intersection, Corridor, Network
FREEVAL	Corridor		
Vissim	Intersection, Corridor, Network		
VDOT Work Zone Tool	Corridor		

Legend

- Intersection
- Corridor
- Network

Software Selection Tool



Software Selection Tool

Project Phase	Analysis Category	Analysis Type	Over / Under Saturated	Location Type	MOE	Microsimulation Required	HCS	Synchro HCM Module
Planning - Visioning Level	Interrupted-Flow Operations Analyses	Conventional Intersection Operations		Segment and Facility	Queue (95th Percentile Queue, Maximum Queue)		✓ 95th Percentile Queue	✓ 95th Percentile Queue
Planning - Visioning Level	Interrupted-Flow Operations Analyses	Conventional Intersection Operations		Segment and Facility	Delay (Control Delay, Microsimulation Delay)		✓ Control Delay	✓ Control Delay
Planning - Visioning Level	Interrupted-Flow Operations Analyses	Conventional Intersection Operations		Point	Delay (Control Delay, Microsimulation Delay)		✓ Control Delay	✓ Control Delay
Planning - Visioning Level	Interrupted-Flow Operations Analyses	Conventional Intersection Operations		Point	Queue (95th Percentile Queue, Maximum Queue)		✓ 95th Percentile Queue	✓ 95th Percentile Queue

Calibration and Validation

Document consideration of the following factors:

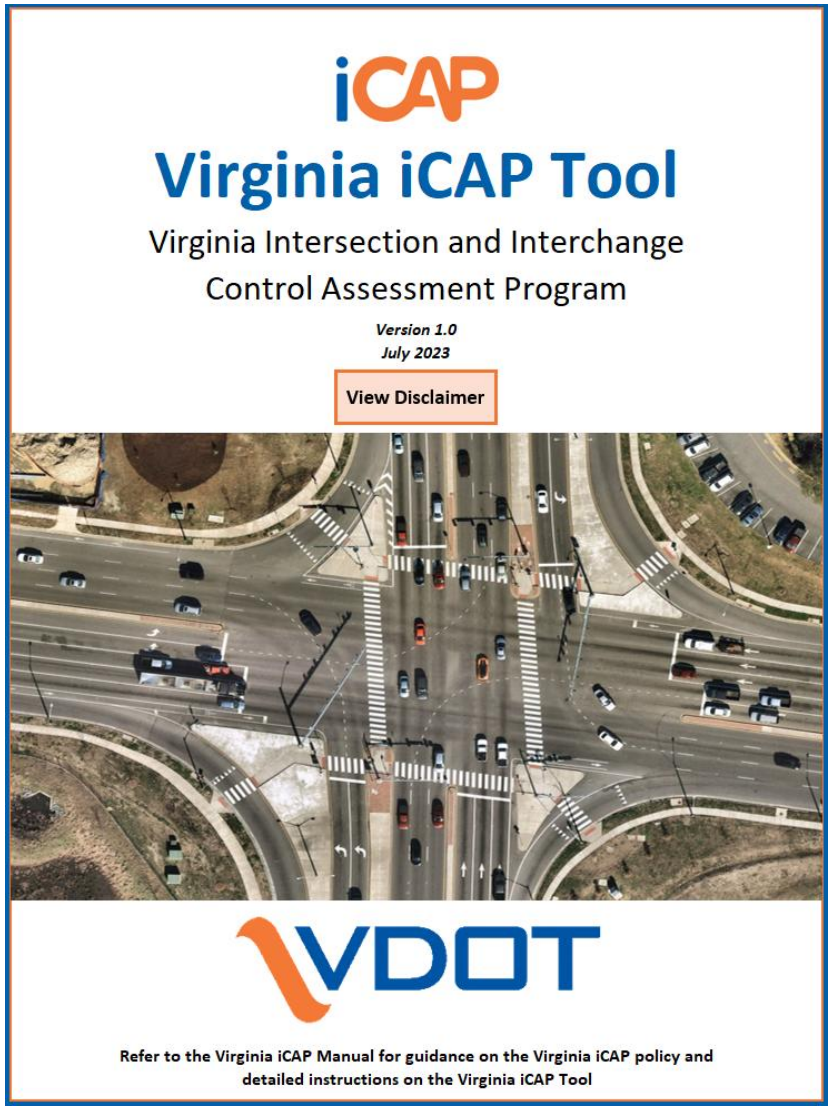
- Calibration measures
- Critical links
- Calibration thresholds
  - Adherence to calibration thresholds is the expected standard for most traffic analyses.
  - The DTE shall approve adjusted thresholds warranted by specific situations.

Goals for Alternatives Prioritization Using iCAP

- ✓ Arrive at Optimal solutions
- ✓ Based on Objective Performance Metrics
- ✓ By Consistent Comparison of Alternatives, and
- ✓ A Transparent Process
- ✓ With Clear Documentation

And an Increased awareness of innovative solutions at intersection and interchange.

Alternatives Prioritization using iCAP Assessment Tool



VIRGINIA ICAP APPLICABILITY FORM

iCAP Intersection & Interchange Control Assessment Program

Evaluator: _____ **Date:** _____

PROJECT LOCATION

Locality/County: _____

Location: _____

Is the project located on the Arterial Preservation Network (APN)?[1] Yes

➔ *If Yes, complete section A. If No, complete section B.*

A) APPLICABILITY FOR LOCATIONS ON THE APN

PROJECT PURPOSE AND NEED:

Does the project purpose and need indicate intersection or interchange control should be evaluated? No

➔ *If Yes, proceed to Performance Based Practical Design*

➔ *If No, an iCAP assessment is not required*

PERFORMANCE BASED PRACTICAL DESIGN:

If the existing intersection is signalized, can operational and safety issues be resolved with changes to signal phasing and timing? Not Applicable

➔ *If Yes, an iCAP assessment is not required*

➔ *If No, an iCAP assessment is required*

B) APPLICABILITY FOR LOCATIONS OFF THE APN

PROJECT PURPOSE AND NEED:

Is a signal recommended as the intersection traffic control? Not Applicable

➔ *If Yes, conduct Stage 1 iCAP assessment and warrant study per the latest version of IIM-TE-387*

➔ *If No, an iCAP assessment is not required*

ASSESSMENT REQUIREMENT AND APPROVAL

Document the analysis required and submit to the VDOT District Traffic Engineer or designee for approval.

Required Assessment: Full iCAP Assessment Required

Reason for Exclusion:

Justification:

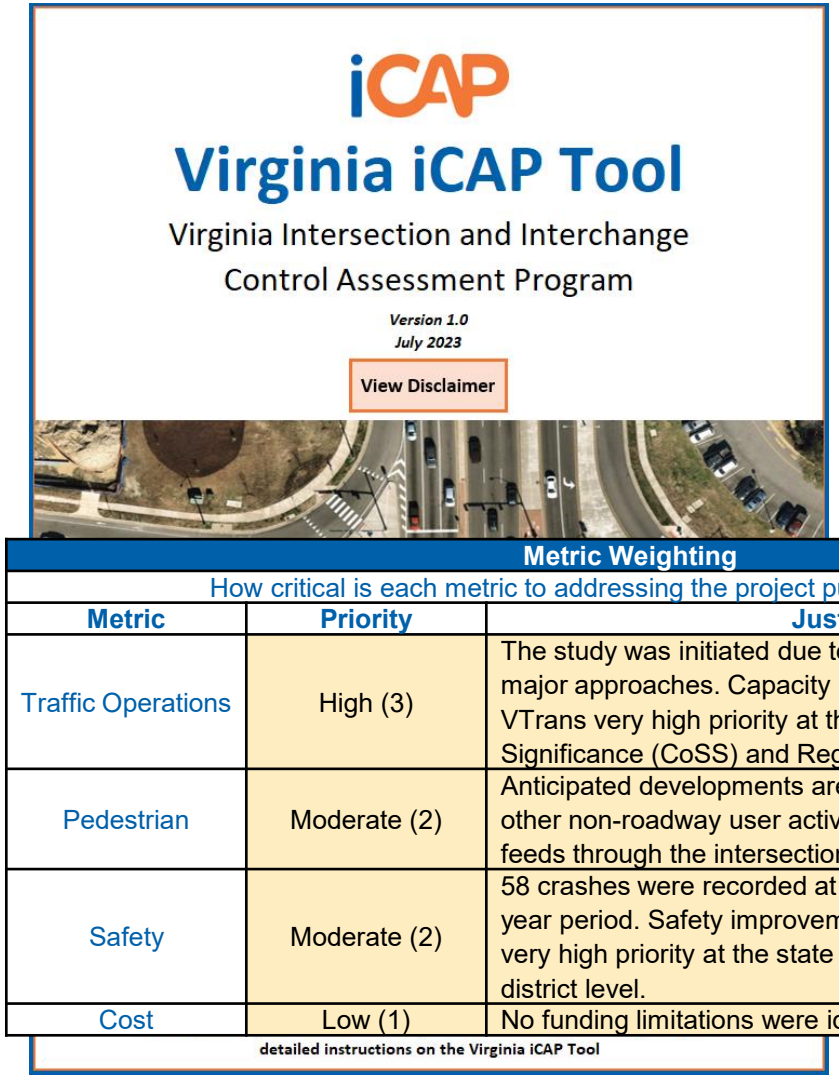
VDOT District Traffic Engineer or designee approval:

Name / Signature _____ Title _____ Date _____

[1] *https://www.virginiadot.org/programs/vdot_arterial_preservation_program.asp*

VDOT

Alternatives Prioritization using iCAP Assessment Tool



Locality/County	Prince William County
Location	Intersection of Route 234 and Route A
Is the Intersection/Interchange Located on the APN?[1]	Yes
Project Type	Intersection Improvement
Project Description	iCAP v11 Sample Project
Current Year	2022
Design Year or Future Year	2040

Traffic and Safety Conditions[2]	Existing Intersection V/C Ratio	0.39
	Future Intersection V/C Ratio	0.63
	PSI Segment Ranking	N/A
	PSI Intersection Ranking	93

Multimodal Conditions	VDOT Pedestrian Safety Action Plan (PSAP) Corridor?[3]	No
	Bicycle and/or Pedestrian Generator?	Yes

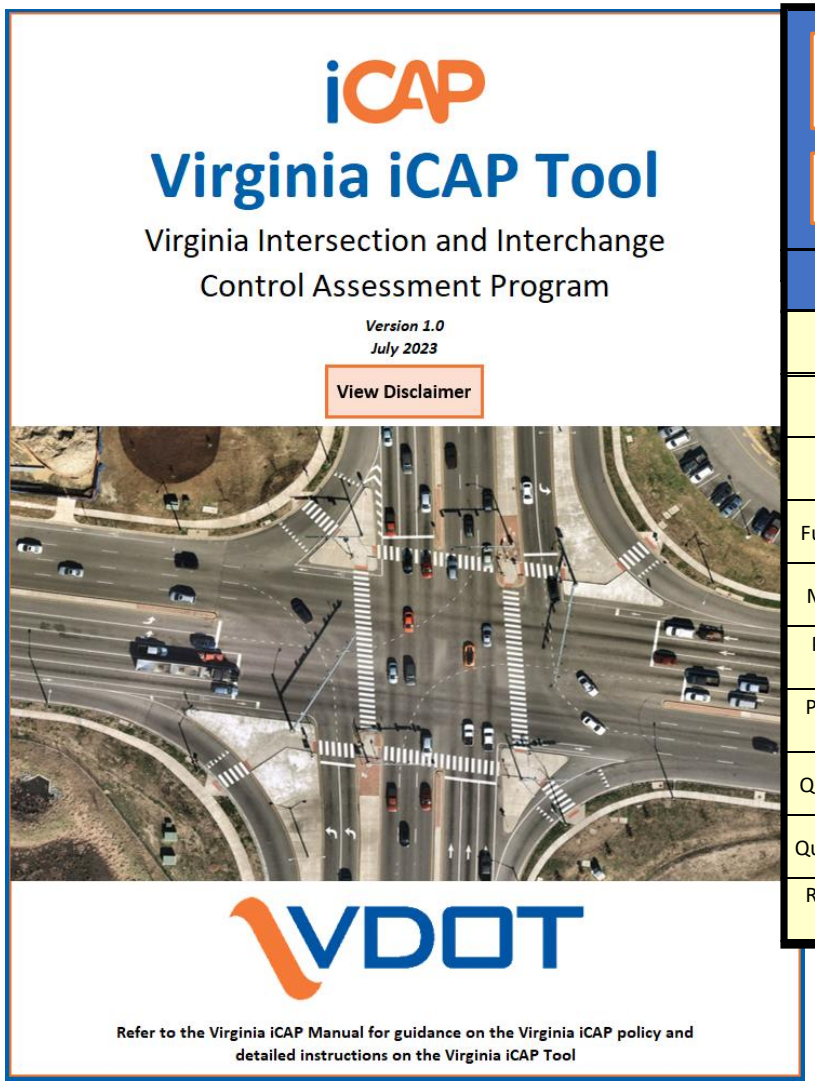
Metric Weighting

How critical is each metric to addressing the project purpose and need?

Metric	Priority	Justification
Traffic Operations	High (3)	The study was initiated due to existing congestion along the major approaches. Capacity preservation was flagged as a VTrans very high priority at the Corridor of Statewide Significance (CoSS) and Regional Network (RN) levels.
Pedestrian	Moderate (2)	Anticipated developments are likely to increase pedestrian and other non-roadway user activity through the multi-use path that feeds through the intersection.
Safety	Moderate (2)	58 crashes were recorded at the study location within the five-year period. Safety improvements were flagged as a VTrans very high priority at the state level and a high priority at the district level.
Cost	Low (1)	No funding limitations were identified for this project.

Related iCAP Metric	VTrans Need	Priority
Traffic Operations	Capacity Preservation	Very High
	Congestion Mitigation	Low
Pedestrian	Pedestrian Access	None
	Pedestrian Safety Improvement	None
	Bicycle Access	None
Safety	Safety Improvement	Very High
	Reliability	None
TDM / Transit / Other	IEDA (UDA) Access	None
	Rail On-time Performance	None
	Transit Access	Low
	Transit Access for Equity Emphasis Areas	None
	Transportation Demand Management	Low

Alternatives Prioritization using iCAP Assessment Tool

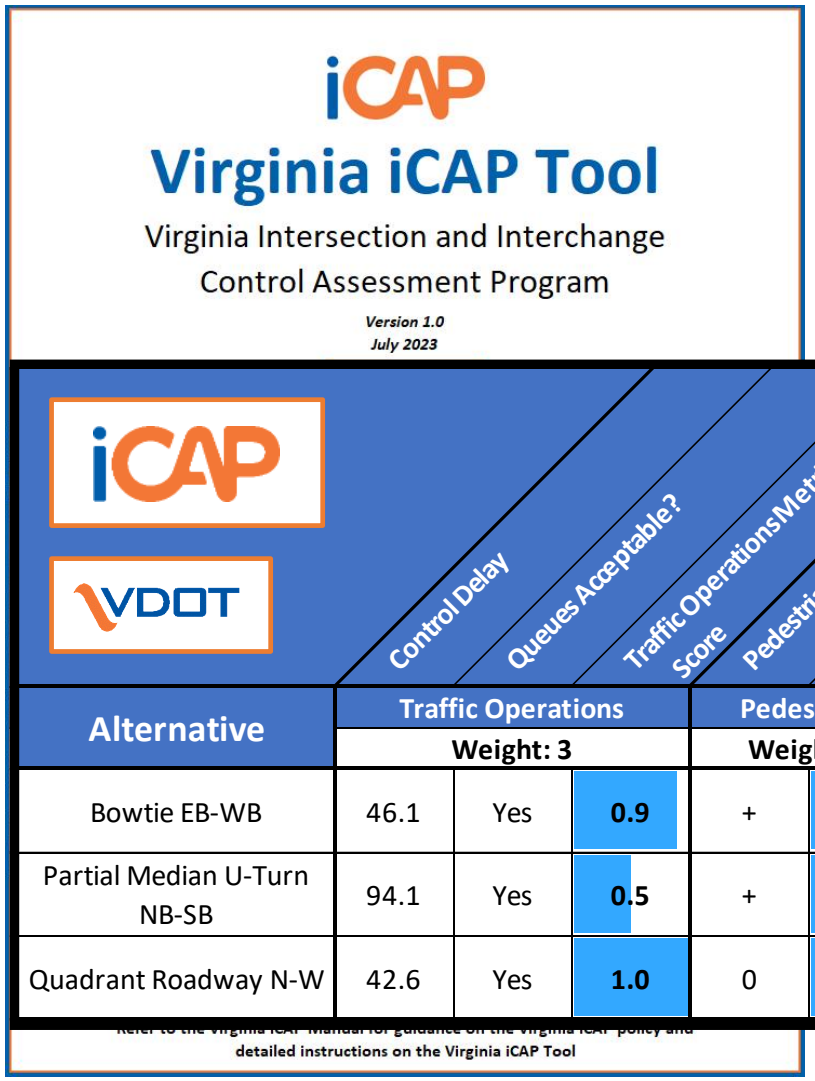


STAGE 1 PERFORMANCE MATRIX
(Table condensed for illustrative purposes)

Case Study:
Route 234 & Route A

Alternative	Traffic Operations Weight: 3		Pedestrian Weight: 2		Safety Weight: 2		Stage 1 Cost Weight: 1		Total Score Out of 8	Selection for Stage 2 and Justification
	Maximum V/C Ratio	Traffic Operations Metric Score	Pedestrian Accommodation	Pedestrian Metric Score	Weighted Total Conflict Points	Safety Metric Score	Planning Level Cost Category	Stage 1 Cost Metric Score		
Conventional	1.23	--	0	--	48	--	--	--	--	--
Bowtie EB-WB	1.04	**0.7**	+	**1.0**	24	**0.9**	$$$	**0.3**	**6.2**	**Yes:** Compatible with roadway geometry and spacing requirements.
Conventional	0.99	**0.9**	0	**0.5**	48	**0.0**	$	**1.0**	**4.7**	**No:** Works operationally, however, limited potential to accommodate for future developments.
Full Displaced Left Turn	0.97	**1.0**	-	**0.0**	40	**0.3**	$$$	**0.3**	**3.9**	**No:** Encroaches on the 100-foot buffer zone and reduces pedestrian access.
Median U-Turn NB-SB	1.10	**0.5**	+	**1.0**	20	**1.0**	$$$$	**0.3**	**5.8**	**No:** Does not accommodate the high number of mainline left turns.
Partial Displaced Left Turn NB-SB	0.97	**1.0**	-	**0.0**	44	**0.1**	$$	**0.5**	**3.7**	**No:** Encroaches on the 100-foot buffer zone and reduces pedestrian access.
Partial Median U-Turn NB-SB	1.02	**0.8**	+	**1.0**	28	**0.7**	$$	**0.5**	**6.3**	**Yes:** Provides limited rerouting of vehicles to u-turns with improved operations and pedestrian access.
Quadrant Roadway N-E	0.97	**1.0**	0	**0.5**	40	**0.3**	$$$$	**0.3**	**4.9**	**No:** Would conflict with proposed development.
Quadrant Roadway N-W	0.97	**1.0**	0	**0.5**	40	**0.3**	$$$$	**0.3**	**4.9**	**Yes:** Compatible with proposed development while providing improvement to operations.
Restricted Crossing U-Turn NB-SB	0.97	**1.0**	0	**0.5**	20	**1.0**	$$$	**0.3**	**6.3**	**No:** Does not accommodate heavy through volumes on the minor street.

Alternatives Prioritization using iCAP Assessment Tool



STAGE 2 PERFORMANCE MATRIX
(Table condensed for illustrative purposes)

Case Study:
Route 234 & Route A

Alternative	Traffic Operations Weight: 3			Pedestrian Weight: 2		Safety Weight: 2		Stage 1 Cost Weight: 1		Total Score Out of 8	Preferred Alternative and Justification
	Control Delay	Queues Acceptable?	Traffic Operations Metric Score	Pedestrian Accommodation	Pedestrian Metric Score	SMART SCALE F+I CMF	Safety Metric Score	Total Estimated Cost	Stage 2 Cost Metric Score		
Bowtie EB-WB	46.1	Yes	**0.9**	+	**1.0**	0.70	**1.0**	$12,557,000	**1.0**	**7.7**	**No:** Improvement to safety and delay, however, the quadrant roadway better facilitates development.
Partial Median U-Turn NB-SB	94.1	Yes	**0.5**	+	**1.0**	0.91	**0.3**	$12,850,000	**1.0**	**5.1**	**No:** Lowest improvement to safety and delay.
Quadrant Roadway N-W	42.6	Yes	**1.0**	0	**0.5**	0.70	**1.0**	$29,593,000	**0.4**	**6.4**	**Yes:** Improvement to safety and delay while better preparing the location for anticipated development.

Alternatives Prioritization using iCAP Assessment Tool

Virginia iCAP Tool

Virginia Intersection and Interchange Control Assessment Program

Version 1.0

iCAP ASSESSMENT OUTPUT

Evaluator Name: VDOT

Evaluation Date: 8/16/2022

Applicability and Project Purpose and Need

Locality/County	Prince William County
Location	Intersection of Route 234 and Route A
Is the Project Located on the APN?	Yes
Project Description	iCAP v11 Sample Project
Current Year	2022
Design Year or Future Year	2040

Project Purpose and Need

The study corridor is a regionally significant corridor which serves both commuting travelers and local travelers. Based on the long-range land use plan, more development is planned along this corridor. The need for access from the planned developments and for capacity on the mainline is significant. The purpose of this project is to identify solutions to not only relieve existing congestion, but to also provide sufficient capacity to accommodate the anticipated growth from regional use and local travelers on this major thoroughfare. The project aims at identifying and evaluating innovative intersection concepts as cost-effective alternatives to grade-separation concepts that are planned for some of the study intersections.

VTrans Need	Priority	Options
Capacity Preservation	Very High	CoSS/RN
Congestion Mitigation	Low	CoSS/RN
Pedestrian Access	None	
Pedestrian Safety Improvement	None	
Bicycle Access	None	
Safety Improvement	Very High	State/District
Reliability	None	
IEDA (UDA) Access	None	
Rail On-time Performance	None	
Transit Access	Low	RN
Transit Access for Equity Emphasis Areas	None	
Transportation Demand Management	Low	CoSS/RN

iCAP Metric Priorities

Metric	Priority	Justification
Traffic Operations	High (3)	Significant congestion issues with more developments planned.
Pedestrian	Moderate (2)	Multiuse trail connection anticipated to
Safety	Moderate (2)	Intersection ranked #93 for PSI, fair number of crashes.
Cost	Low (1)	Important, but not to impede priorities of other metrics.

Volume Data, Crash History, and Multimodal Information

Assessment Scenario Volume Data

Direction	Volume (veh/hr)			Truck %	Daily Pedestrian Volume	Daily Bicycle Volume
	U-Turn / Left	Through	Right			
Eastbound	123	218	345	2.00%	0	0
Westbound	166	406	226	2.00%	3	0
Northbound	420	1872	120	2.00%	0	0
Southbound	60	2121	112	2.00%	0	0

5-Year Crash Data Summary (2016-2020)

Crash Analysis Years	From:	2016	To:	2020
Fatal + Injury Crashes	24			
Pedestrian Crashes	0			
Bicycle Crashes	0			

Existing Multimodal Accommodations

Pedestrian	bound, northbound, and westbound approaches. A multiuse path feeds ir
Bicycle	A multiuse path feeds into the intersection at the southeast corner.
Transit	None.

iCAP ASSESSMENT OUTPUT

Stage 1: Alternatives Screening Performance Matrix

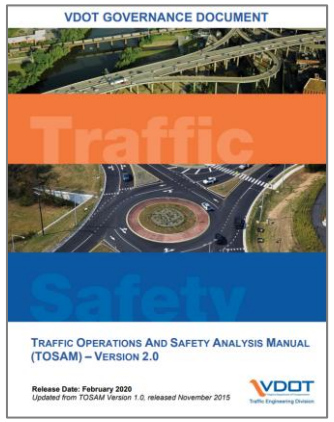
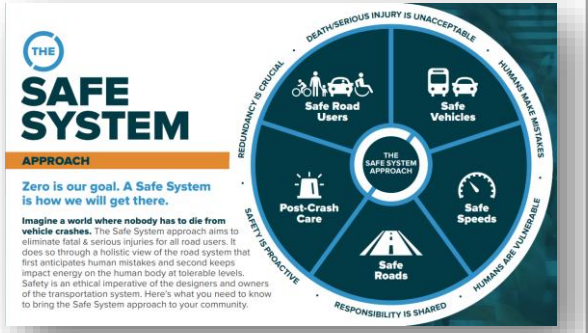
Alternative	Traffic Operations Metric		Pedestrian Metric		Safety Metric		Stage 1 Cost Metric		Total Stage 1 Score	Selected for Stage 2 Analysis?	
	VJuST Maximum V/C Ratio	Score	Accommodation	Score	Conflict Points	Score	Cost Category	Score			
Base Condition	1.23	--	0.00	--	48	--	$	--			
Bowtie EB-WB	1.04	0.7	+	1.0	24	0.9	$$$	0.3	6.2 out of 8	Yes	Compatible with roadway geometry and spacing requirements.
Conventional	0.99	0.9	0	0.5	48	0.0	$	1.0	4.7 out of 8	No	Works operationally, however, limited potential to accommodate for future developments.
Full Displaced Left Turn	0.97	1.0	-	0.0	40	0.3	$$$	0.3	3.9 out of 8	No	Encroaches on the 100-foot buffer zone and reduces pedestrian access.
Median U-Turn NB-SB	1.10	0.5	+	1.0	20	1.0	$$$$	0.3	5.8 out of 8	No	Does not accommodate the high number of mainline left turns.
Partial Displaced Left Turn NB-SB	0.97	1.0	-	0.0	44	0.1	$$	0.5	3.7 out of 8	No	Encroaches on the 100-foot buffer zone and reduces pedestrian access.
Partial Median U-Turn NB-SB	1.02	0.8	+	1.0	28	0.7	$$	0.5	6.3 out of 8	Yes	Provides limited rerouting of vehicles to u-turns with improved operations and pedestrian access.
Quadrant Roadway N-E	0.97	1.0	0	0.5	40	0.3	$$$$	0.3	4.9 out of 8	No	Would conflict with proposed development.
Quadrant Roadway N-W	0.97	1.0	0	0.5	40	0.3	$$$$	0.3	4.9 out of 8	Yes	Compatible with proposed development while providing improvement to operations.
Restricted Crossing U-Turn NB-SB	0.97	1.0	0	0.5	20	1.0	$$$	0.3	6.3 out of 8	No	Does not accommodate heavy through volumes on the minor street.
Metric Weighting	3		2		2		1				

Stage 2: Alternatives Assessment Performance Matrix

MOE 1: *Control Delay* **MOE 2:** *95th Percentile Queue Length*

Alternative	Traffic Operations Metric			Pedestrian Metric Score	Safety Metric		Stage 2 Cost Metric		Total Stage 2 Score	Preferred Alternative?
	MOE 1 Score	MOE 2 Score	Total Score		Annual F+I Crash Reduction	Score	VJuST-C Cost Estimate	Score		
Bowtie EB-WB	0.9		0.9	1.0	1.44	1.0	$ 12,557,000	1.0	7.7 out of 8	No: Improvement to safety and delay, however, the quadrant roadway better facilitates development.
Partial Median U-Turn NB-SB	0.5		0.5	1.0	0.43	0.3	$ 12,850,000	1.0	5.1 out of 8	No: Lowest improvement to safety and delay.
Quadrant Roadway N-W	1.0		1.0	0.5	1.44	1.0	$ 29,593,000	0.4	6.4 out of 8	**Yes: Improvement to safety and delay while better preparing the location for anticipated development.**
					0.00	0.0				
					0.00	0.0				
Metric Weighting	3			2	2		1			

Tools for iCAP Stage 2 (Detailed Analytics)

Traffic Operations	Pedestrian	Safety	Cost
 Such as… Synchro® plus SimTraffic® PTV VISSIM the mind of movement SIDRA INTERSECTION	VJuST VDOT Junction Screening Tool 	VDOT Virginia Department of Transportation VIRGINIA STATE PREFERRED CMF LIST	VJuST-C VDOT Junction Screening Tool Cost Estimate Module

Update Traffic Operations and Safety Analysis Manual (TOSAM) ver 2.0

Detailed analysis requirement and guidance for traffic studies

- ✓ **Incorporate Guidance from revised IIM-TOD-397, IIM-TOD-401 and other relevant manuals and guidance**
- ✓ **Best Practices Research that includes Ped/Bike and Safety**
- ✓ **Update Scoping Chapter to include iCAP process and Signal study**
- ✓ **Guidance on updated Software Versions:**
  - HCS
  - Synchro and SimTraffic
  - SIDRA
  - VISSIM
- ✓ **NEW Guidance**
  - Ped/Bike Evaluation
  - Safety Evaluation
  - Mesoscopic modeling
- ✓ **Additional guidance based on Stakeholder Feedback**
  - Data
  - Performance Measures
  - Calibration
- ✓ **Updated Macro Tools, Checklists, and Templates**

Questions??

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Resource Page

VDOT Programs, Instructional & Informational Memorandums, Manuals	URL
iCAP Virginia Intersection and Interchange Control Assessment Program	https://www.vdot.virginia.gov/about/our-system/highways/innovative-intersections/virginia-icap/
Virginia Intersection and Interchange Control Assessment Program (iCAP) Policy and Guidance (IIM-TOD-397)	https://www.vdot.virginia.gov/media/vdotvirginiagov/about/vdots-transportation-system/highways/innovative-intersections/iim-tod-397-icap-policy-and-guidance.pdf
Signal Justification Reports (SJRs) For New and Reconstructed Signals (IIM-TE-387.1*) ***to be Revised to IIM-TOD-401**	https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/location-and-design/roadway-design/TE-387_Signal_Justification_Reports_acc10202023_PM.pdf
Innovative Intersection/ Interchange Committee (IIM-TE-389)	https://www.vdot.virginia.gov/media/vdotvirginiagov/about/vdots-transportation-system/highways/innovative-intersections/iim-te-389-innovative-intersection-interchange-committee.pdf

Resource Page Continued

VDOT Programs, Instructional & Informational Memorandums, Manuals	URL
Arterial Preservation Program	https://www.vdot.virginia.gov/about/programs/arterial-preservation/
Process for Designating Arterial Preservation Network (APN) Corridors and Conducting Planning Studies on the Network (IIM-TMPD-2.1)	https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/transportation-and-mobility/IIM2.1---Corridor-Planning-Studies-AMPs-(12.19)acc11252024.pdf
Strategically Targeted Affordable Roadway Solutions (STARS) Program (IIM-TMPD-3.1)	https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/transportation-and-mobility/iim-tmpd-3.1-stars_acc2025-03-03.pdf

Resource Page Continued

VDOT Programs, Instructional & Informational Memorandums, Manuals	URL
Development of Justification for Additional or Revised Access Points; Creation of Interchange Access Reports (IAR) and Operational and Safety Analysis Reports (OSAR) (IIM-LD-200.11)	https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/location-and-design/migrated/iim/IIM200_acc04162024.pdf
Review of site plans and subdivision plat (IIM-LU-500.3)	https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/land-use-and-development/IIM-LU-500Approved.pdf
Access Management Spacing Exceptions/Waivers (IIM-LU-501.3)	https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/land-use-and-development/IIM-LU-501Approved.pdf

Resource Page Continued

VDOT Programs, Instructional & Informational Memorandums, Manuals	URL
Traffic Operations and Safety Analysis Manual (TOSAM)	https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/traffic-operations/traffic-operations-and-safety-analysis-manual-tosam.pdf
Road Design Manual	https://www.vdot.virginia.gov/doing-business/technical-guidance-and-support/technical-guidance-documents/road-design-manual/

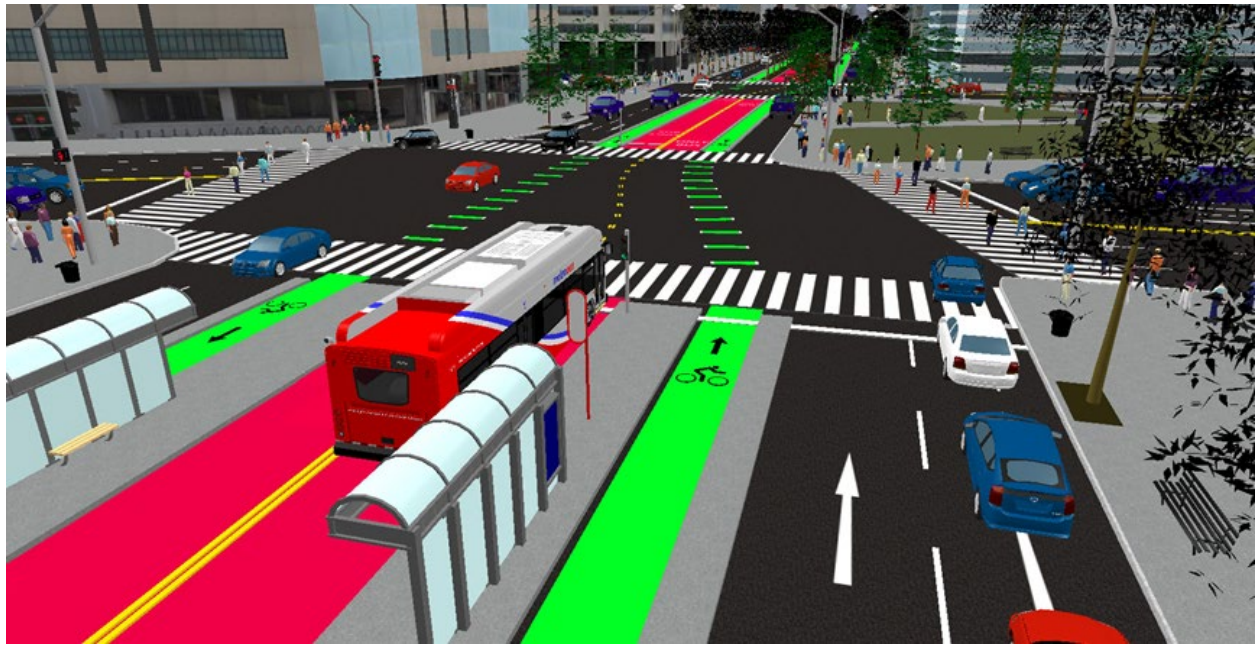
VDOT Networks	URL
Corridors of Statewide Significance – Virginia Department of Transportation	https://www.arcgis.com/home/item.html?id=dc3c258ab660487884f077eec7dd9174
Arterial Preservation Network	https://vdot.maps.arcgis.com/apps/webappviewer/index.html?id=6a024b2739e44b5b8599d86aa3b2c6d7

DOT Practices for Operational Traffic Simulation Models

TRB Webinar
November 6, 2025

Henry Brown, P.E.
Praveen Edara, Ph.D., P.E., P.T.O.E.
Zhu Qing, Ph.D. , P.E.
University of Missouri
Britton Johnson (Hammit), Ph.D., P.E.
Ahmad Abdallah
Kimley-Horn

NCHRP Synthesis Report 650 (2025)



Courtesy of Kimley-Horn, Made with Vissim software

Mizzou

Disclaimer

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Presentation Outline

- Introduction
- General Resources
- DOT Survey
- DOT-Specific Resources
- Case Examples
- Conclusion and Recommendations for Future Research

Motivation, Objective, and Methodology

Motivation

- Use of traffic operational simulation modeling as a tool
  - Planning
  - Design
  - Operations
- Need for understanding of DOT practices

Objective

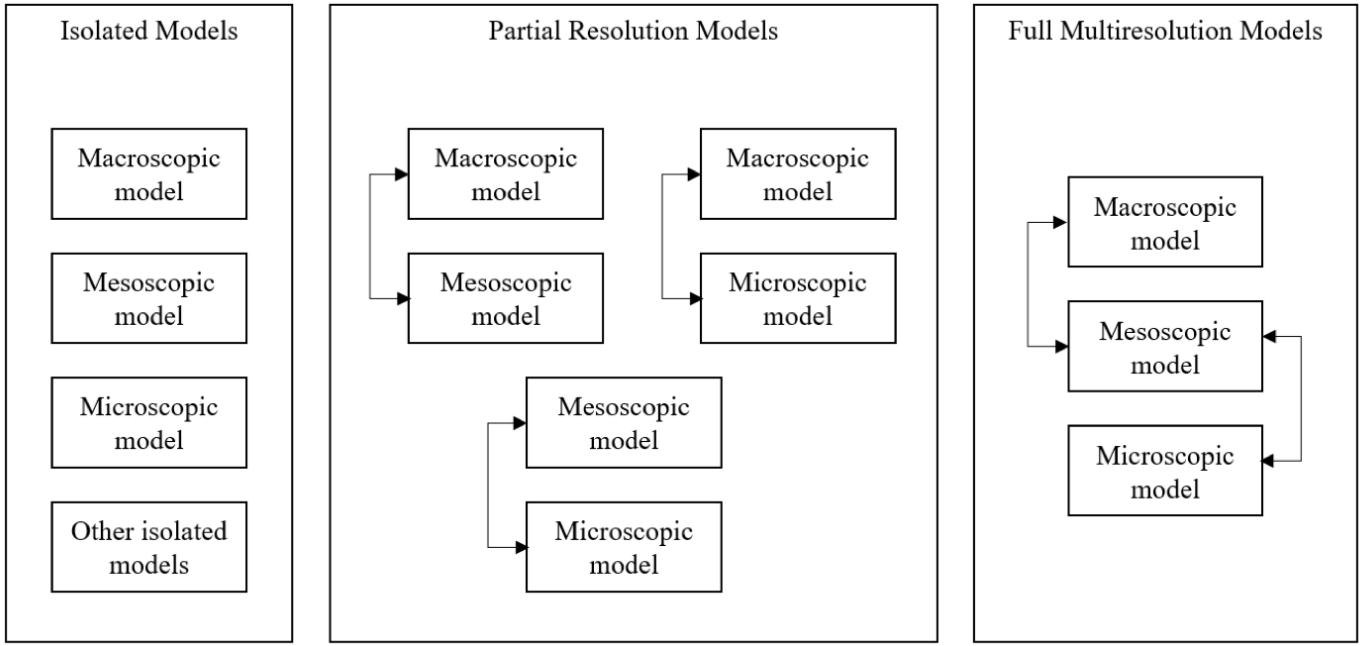
- Review and document DOT practices for operational traffic simulation models

Methodology

- Literature Review
- DOT survey and case examples (interviews)

Overview of Operational Traffic Simulation Modeling

- Operational traffic simulation modeling: A mathematical representation of a transportation system developed using computer software that simulates the movement of traffic over a user-defined transportation network and provides results through reports and animation.
- Modeling resolutions
  - Macroscopic
  - Microscopic
  - Mesoscopic
  - Multi-resolution modeling (MRM)

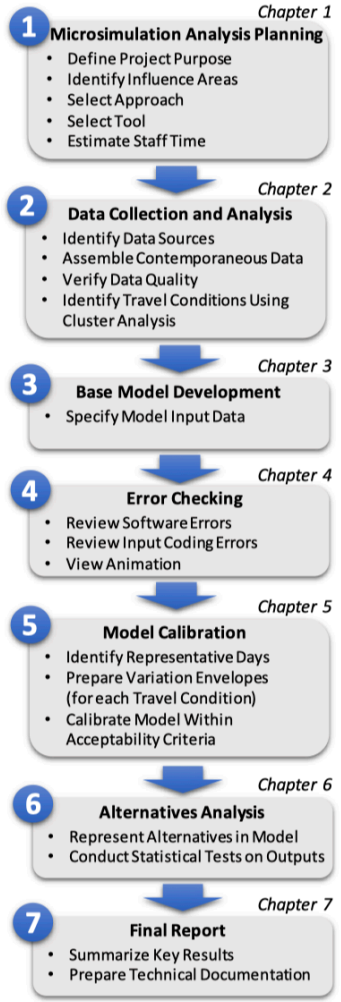


Frameworks for MRM

Source: Zhou et al. 2021

General Resources for Operational Traffic Simulation Modeling

- Traffic Analysis Toolbox (TAT)
  - 2004 Primer (Volume I) (Alexiadis et al. 2004)
    - Tool selection
  - 2004 (Volume III) (Dowling et al. 2004)
    - Seven-step process for microsimulation modeling
  - 2019 (Volume III update) (Wunderlich et al. 2019)
    - More detailed guidance
    - Cluster analysis
    - Time-variation envelopes
    - Data requirements
- Transportation System Simulation Manual
  - Transferred to ACP80 for further development (List 2021)

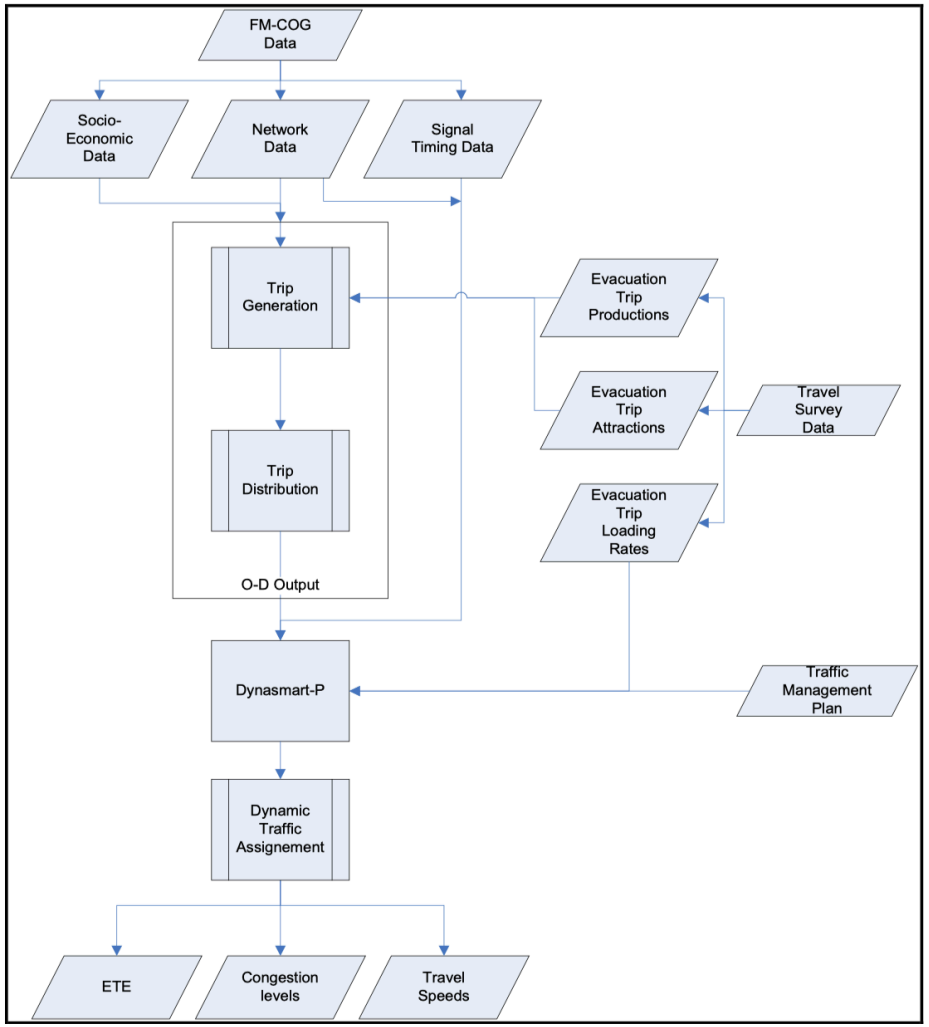


Microsimulation Modeling Process in 2019 TAT

Source: Wunderlich et al. 2019

Example Applications of Operational Traffic Simulation Modeling in Literature

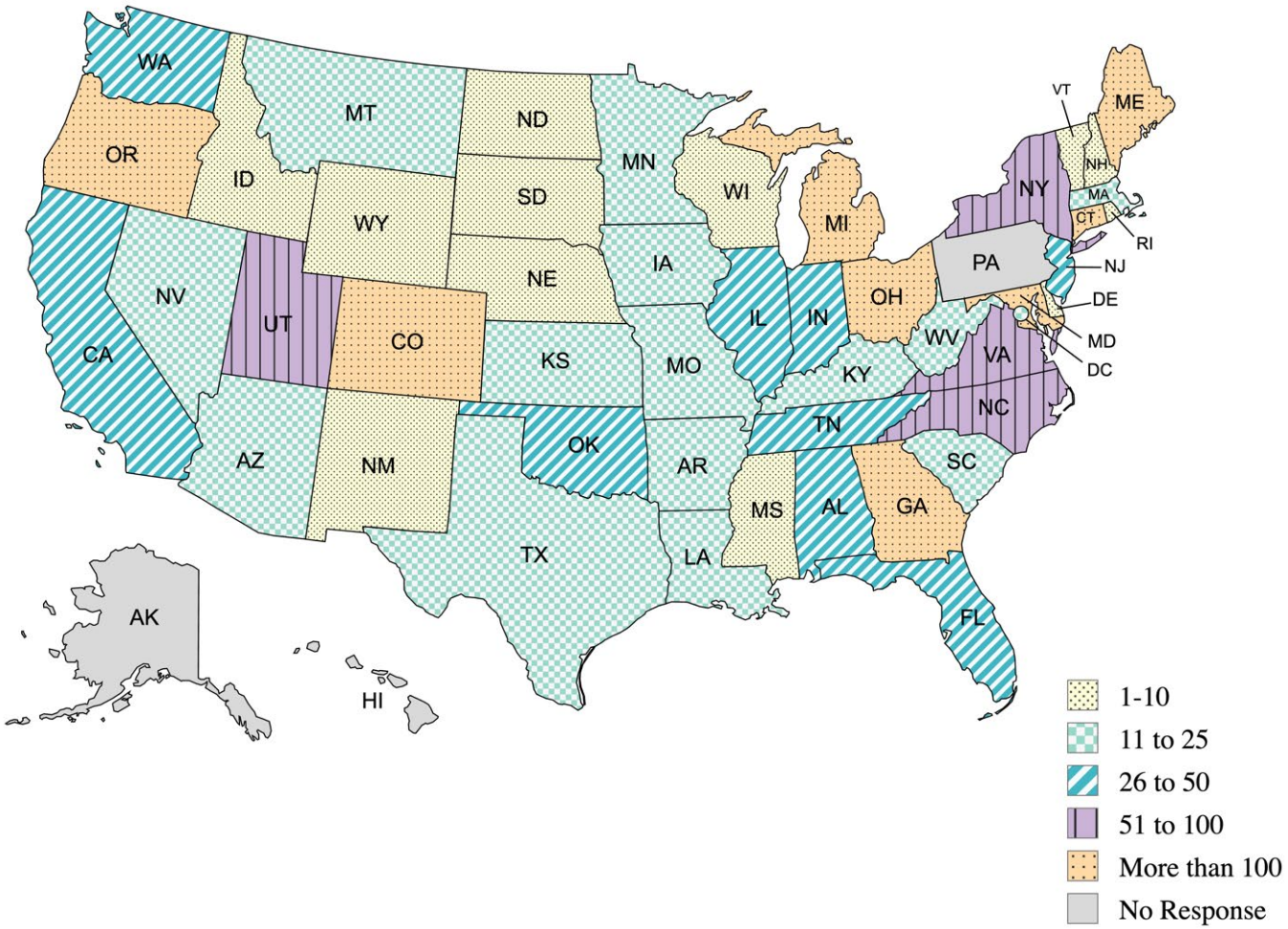
- Impacts of connected and automated vehicles on Virginia freeways (Kim et al. 2021)
- Conversion from one-way to two-way streets (Liu et al. 2021)
- Real-time dynamic noise mapping (Baclet et al. 2023)
- Evaluate delay impacts of light rail and non-motorized modes (Kodupuganti and Pulugurtha 2023)
- Operational analyses at-grade rail crossings (Creasey and Choi 2023)
- Hurricane/emergency evacuation (Chang and Edara 2018, Naser and Birst 2010)



Hybrid Evacuation Modeling Methodology

Source: Naser and Birst 2010

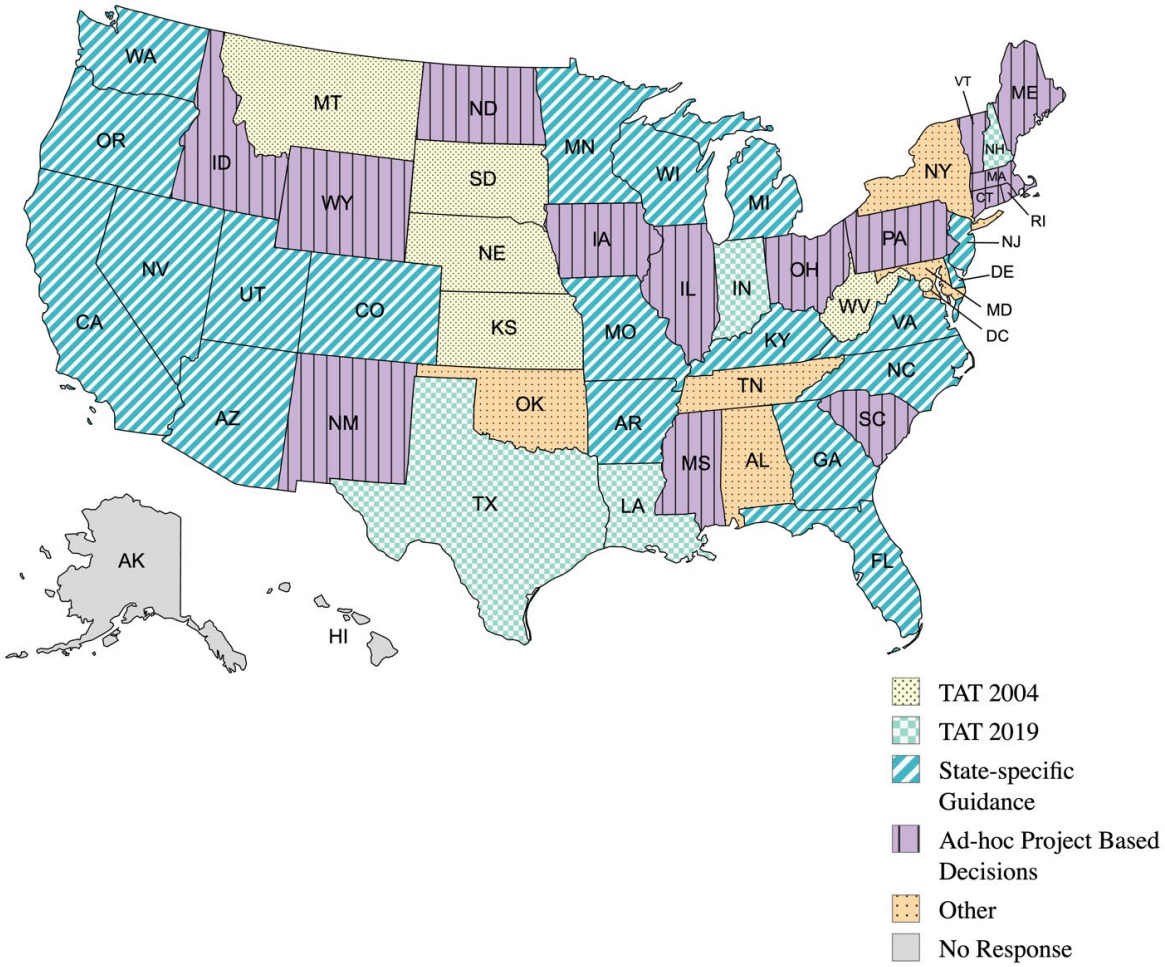
Survey Findings: Extent of Use of Simulation Models



Number of Projects Per Year Using Simulation Models by DOT

Source: Map created with mapchart.net

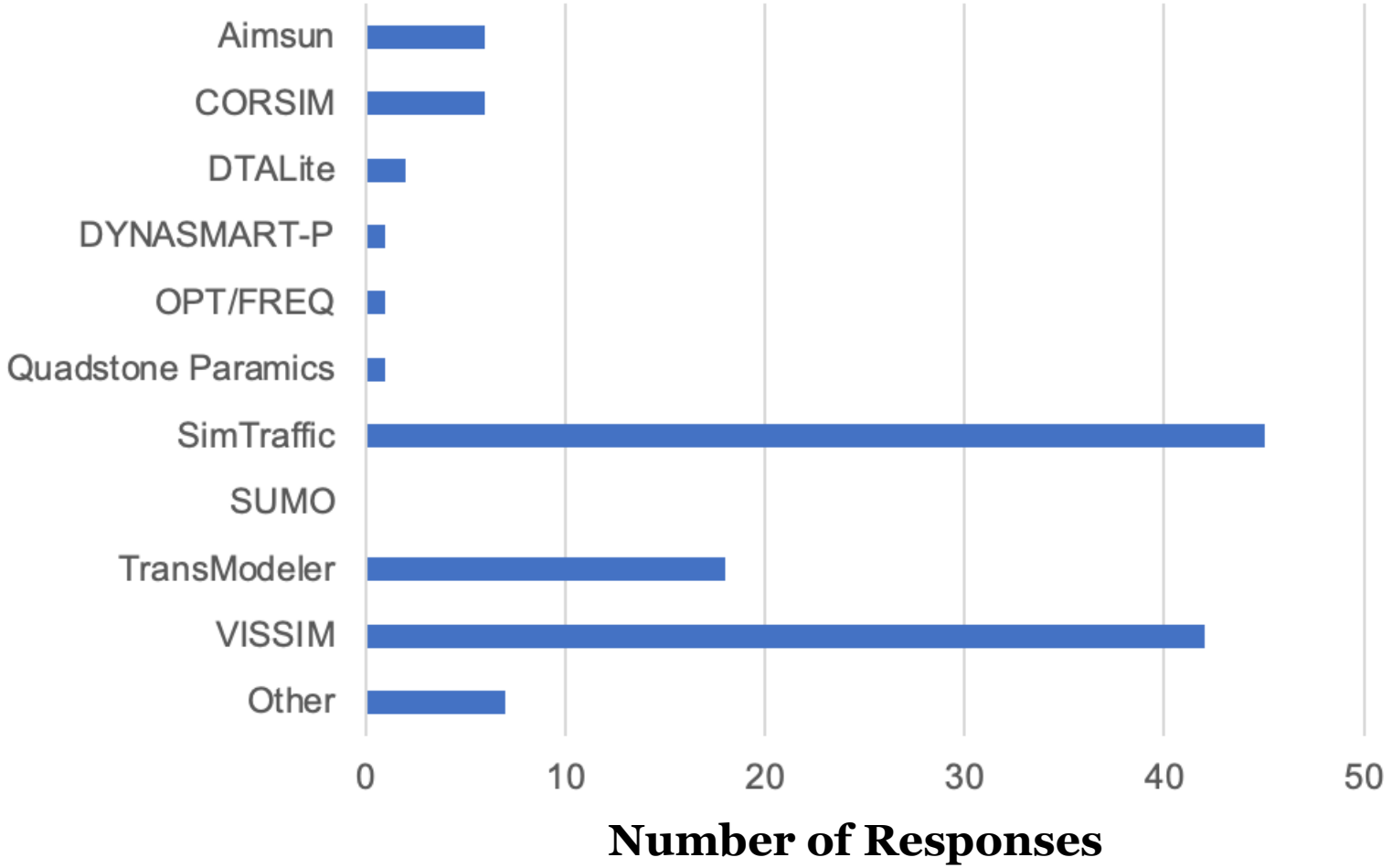
Survey Findings: Use of Guidance



Use of Simulation Guidance by DOT

Source: Map created with mapchart.net

Survey Findings: Use of Software



Use of Simulation Software

Other Key Survey Findings (1 of 2)

Extent of Use and Applications	
Number of responding DOTs that use operational traffic simulation models	49
Average percentage of projects for which responding DOTs use operational traffic simulation models.	31.9%
Number of responding DOTs that require approval for the use of operational traffic simulation models on each project	18

Extent of Use and Applications	
Application used by highest number of responding DOTs	Signal retiming analyses
Number of responding DOTs that use operational traffic simulation models most frequently for freeways	23

Modeling Practices	
Most used simulation modeling resolution	Microscopic
Most used calibration metric	Volumes

Data	
Software used by highest number of responding DOTs	SimTraffic
Most used data source	Traffic counts

Other Key Survey Findings (2 of 2)

Review and Documentation	
Most used review process	Reviews of performance measures
Deliverable required by highest number of responding DOTs	Summary of MOEs

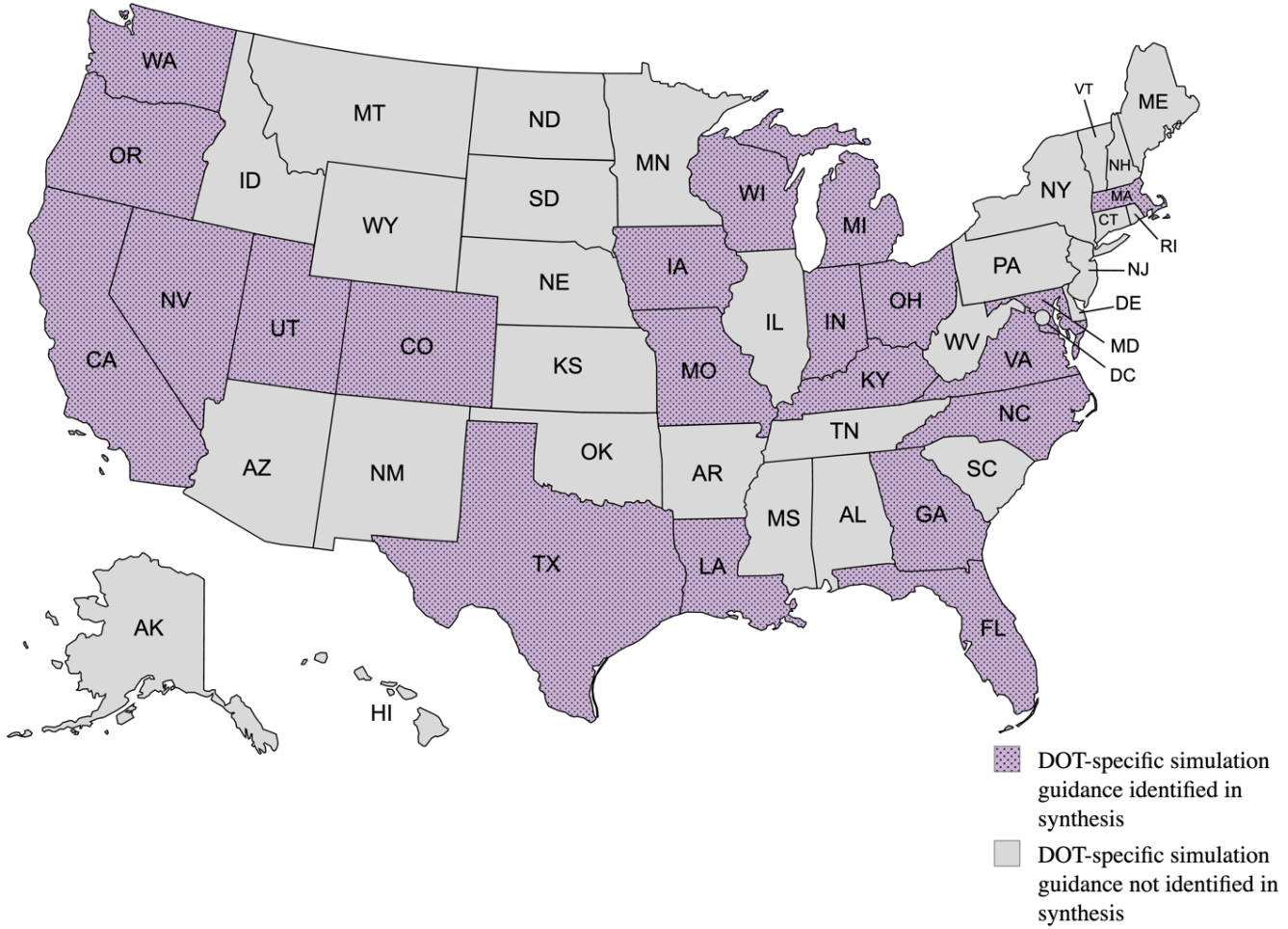
Staffing, Management, and Training	
Most prevalent division for DOT staff	Operations
Number of responding DOTs that utilize consultants for more than 75% of their operational traffic simulation models	27
Number of responding DOTs that have developed training materials	11

Guidance and Other Resources	
Guidelines used by highest number of responding DOTs	State-specific guidance

DOT Resources: Overview

Review of published guidelines for simulation modeling

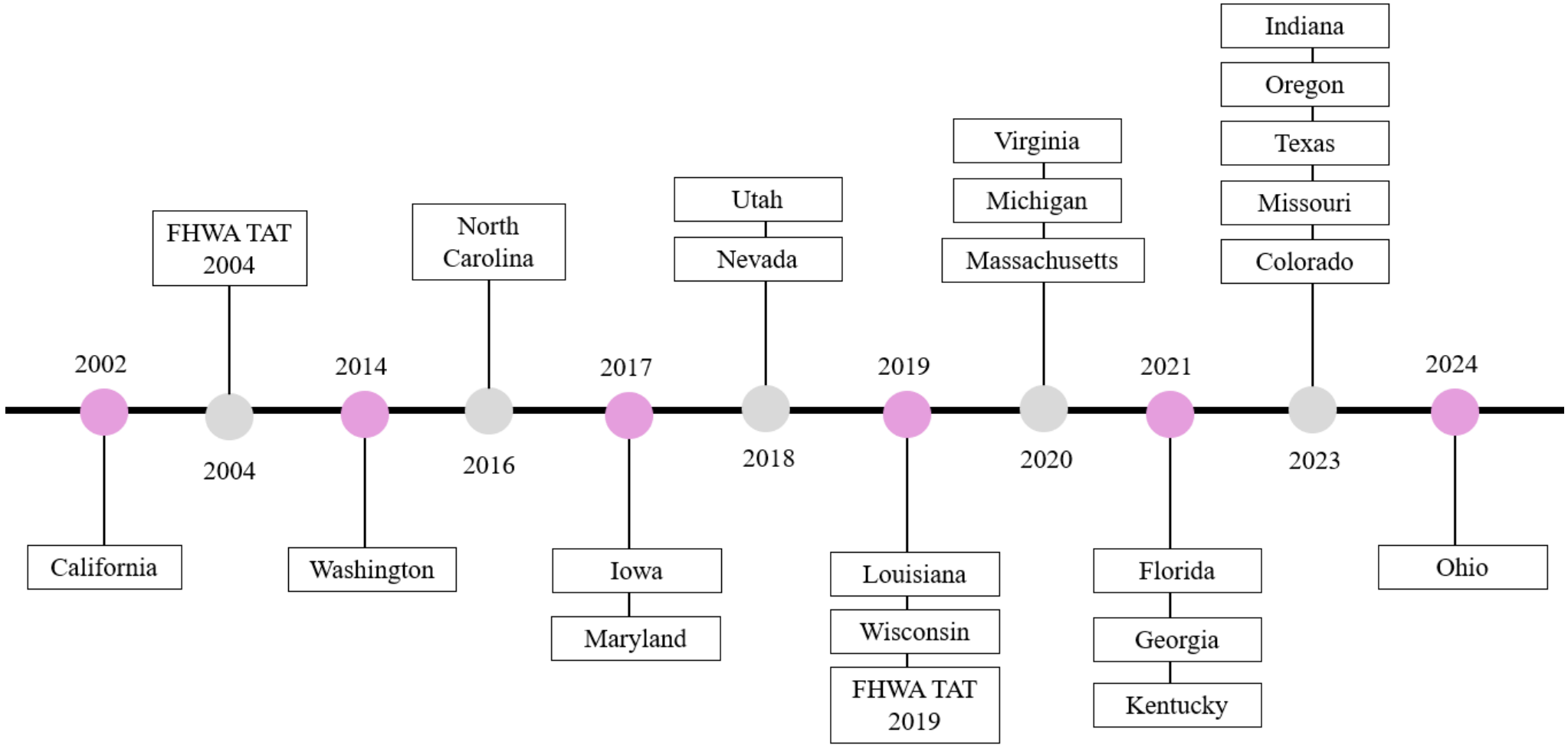
- 21 state DOTs
  - Context of statewide traffic analysis guidelines (10)
  - Operational traffic simulation (11)
  - Software-specific resources (19)
  - Details for model coding and calibration (16)
  - Model review checklists (11)



Map of DOTs with Identified Guidelines

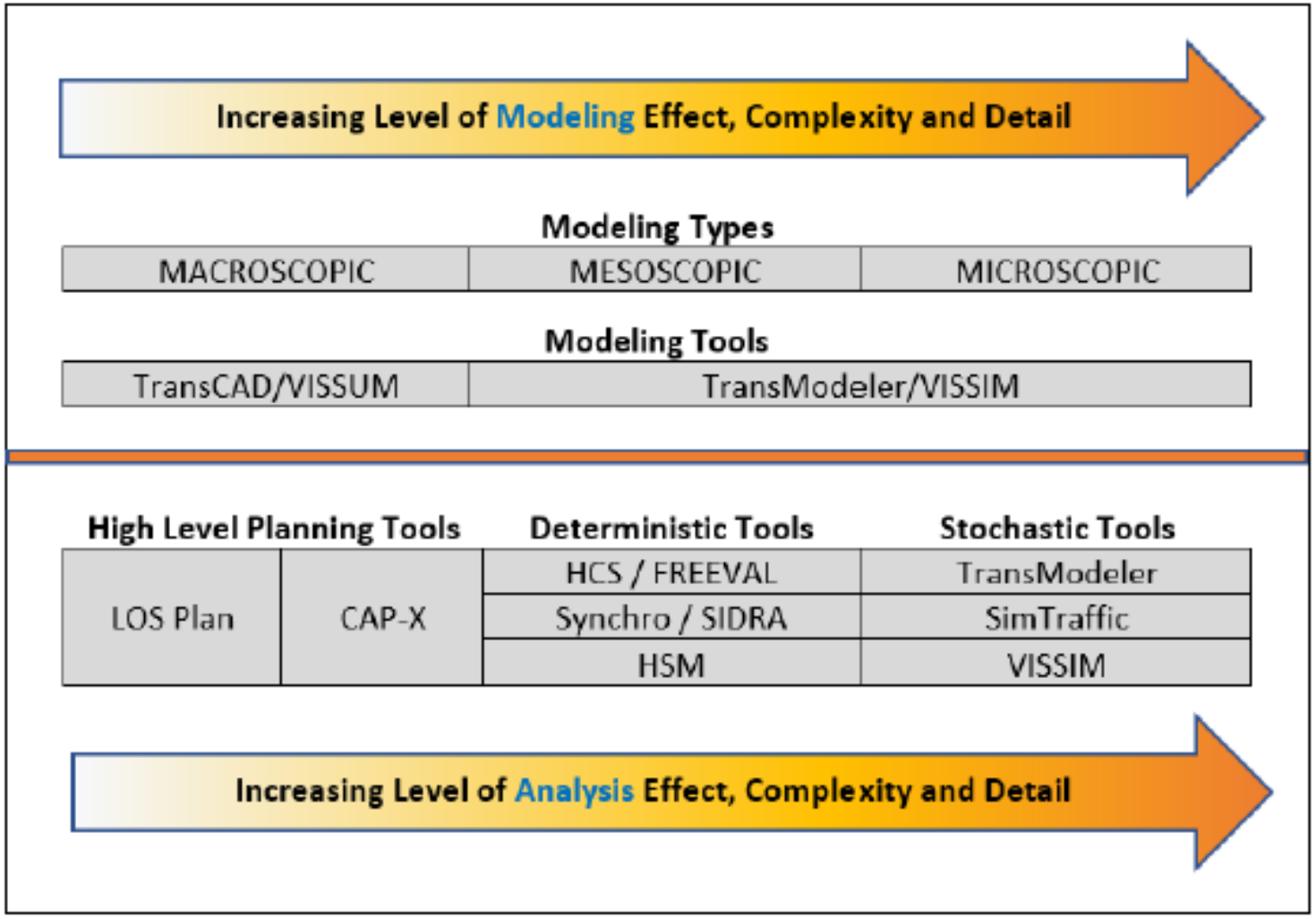
Source: Map created with mapchart.net

DOT Resources: Timeline



Timeline of Guidance Development

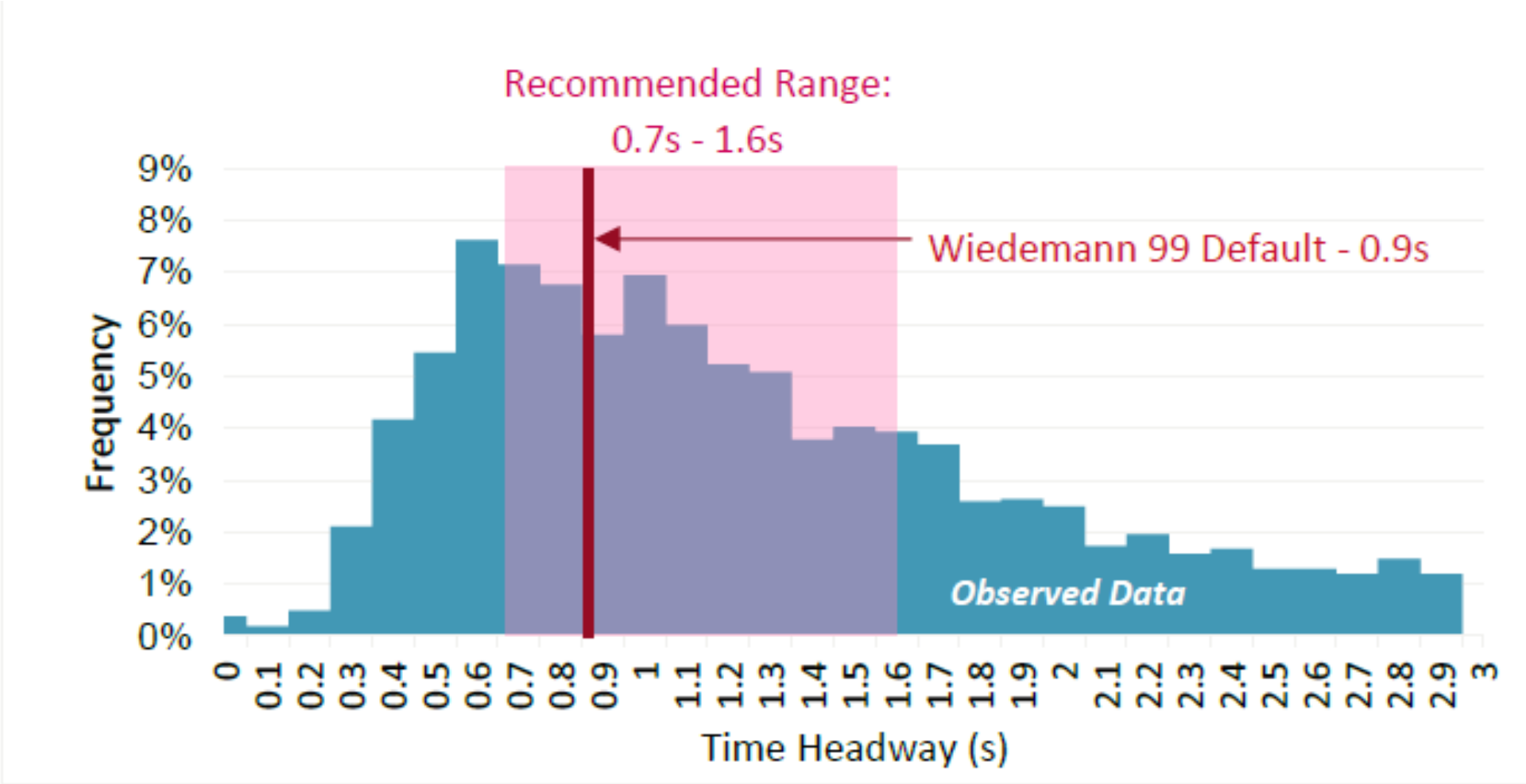
DOT Resources: Selecting the Appropriate Tool



Traffic Analysis Tool Degree of Complexity

Source: Colorado DOT 2023

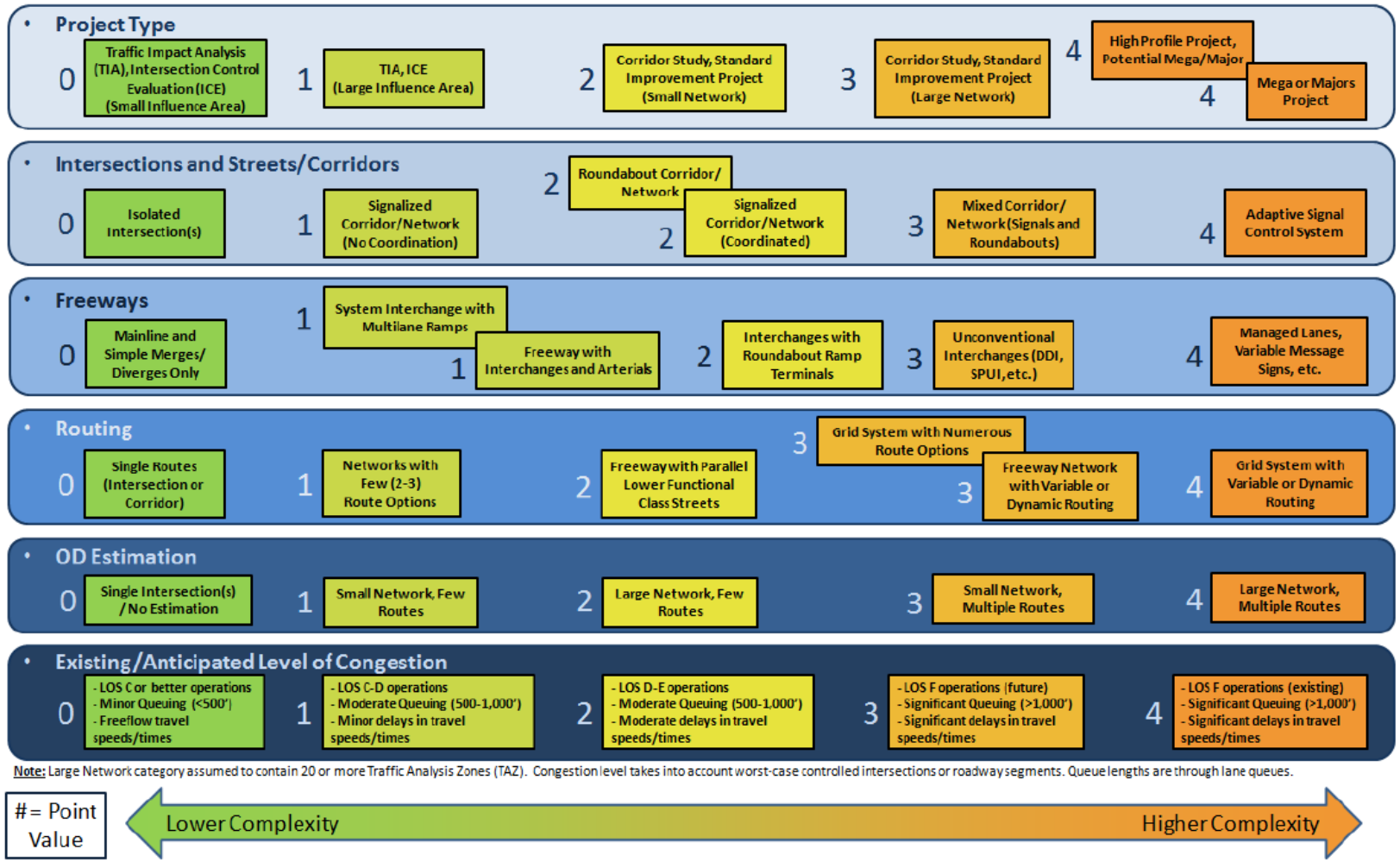
DOT Resources: Calibration



Microsimulation Parameter Quick Reference Spreadsheet

Source: Kentucky Transportation Cabinet 2021

DOT Resources: Review Processes

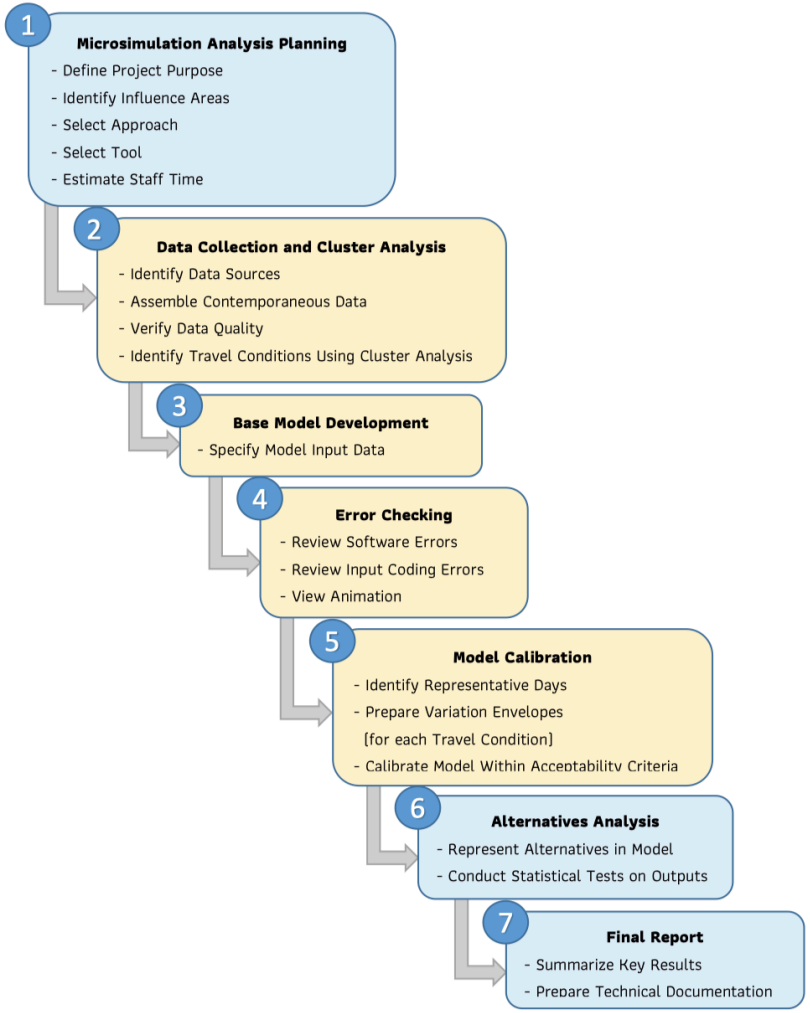


Traffic Model Complexity Scoring Diagram

Source: © 2019 Wisconsin DOT

Case Example Overview: 1 of 2

- Colorado DOT
  - Environmental and planning stage
  - Updated guidance (Colorado DOT 2023)
  - Clustering on project-specific basis
- Indiana DOT
  - Freeways (e.g., complex interchanges)
  - Initial project scoping meeting
  - Use of 2004 and 2019 TAT, guidelines and resources of other states
- South Carolina DOT
  - Alternative analysis, interchange modifications
  - Use of 2004 TAT
  - Modeling and review by Central Office
  - Initial project scoping meeting

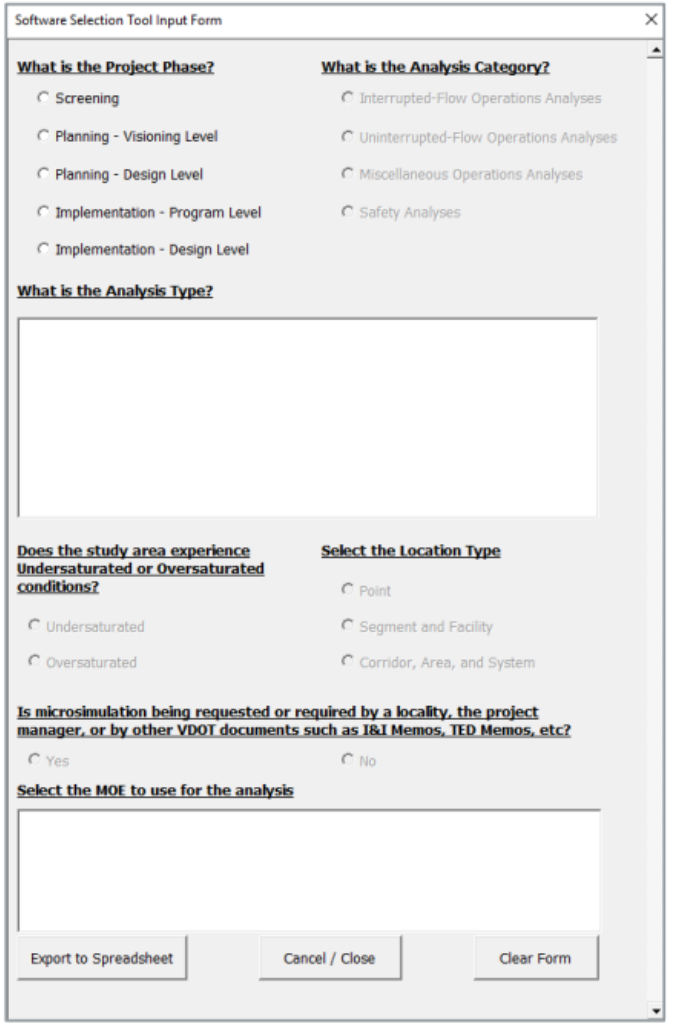


Colorado DOT Microsimulation Modeling Process

Source: Colorado DOT 2023

Case Example Overview: 2 of 2

- Texas DOT
  - Complex interchanges
  - State-specific guidance (Texas DOT 2024)
  - Primarily in Metro and Urban districts
  - Use of hybrid MRM
- Virginia DOT
  - Complex geometries, oversaturated conditions
  - State-specific guidance (Virginia DOT 2020a, 2020b)
  - Developed and facilitated training sessions
- Washington State DOT
  - Planning for complex projects
  - Use of 2004 TAT and state-specific VISSIM protocol (Washington State DOT 2014)
  - Local agencies

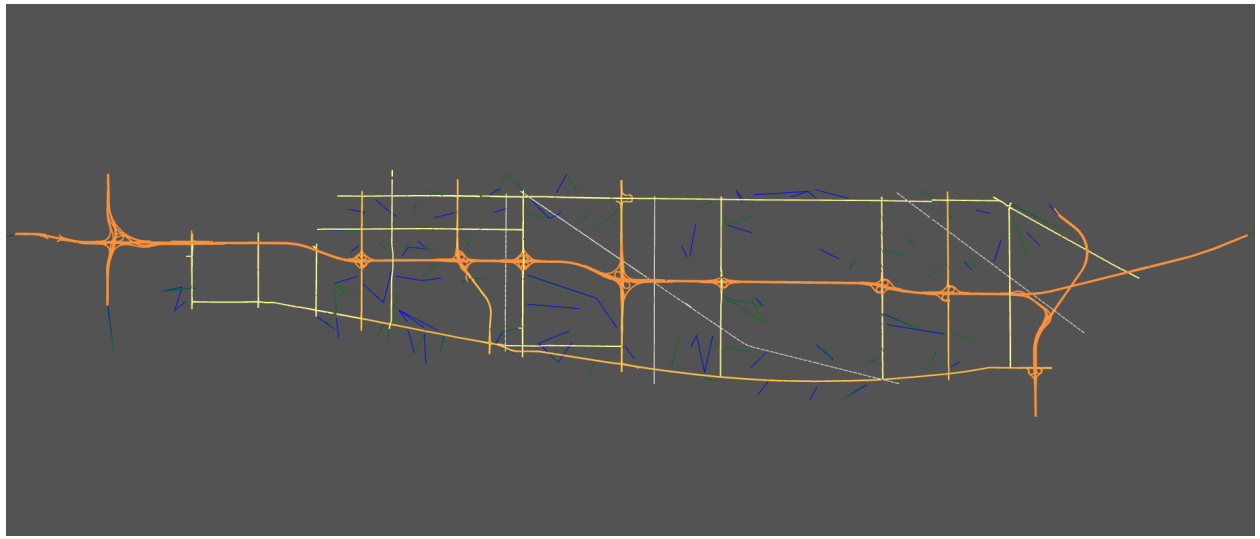


Virginia DOT Software Selection Tool Input Form

Source: © 2020a Virginia DOT

Project Example: I-80/94 Borman Expressway Indiana DOT)

- One of first to use 2019 TAT
- Evaluate TSMO strategies (e.g., dynamic shoulder lanes, ramp metering)
- Use of Aimsun
- Data sources
  - National Performance Management Research Data Set (speeds)
  - Northwestern Indiana Regional Planning Commission Travel Demand Model
  - StreetLight O-D data
- Cluster analysis
  - AM, PM peaks
  - Incidents
  - Weather events
  - Fri pm
  - Summer Sunday pm
- Several strategies in design phase



Screenshot of Model Extents

Source: Courtesy of Parsons

Project Example: Mulkiteo Ferry Terminal (Washington State DOT)

- A business case for the addition of an elevated structure for pedestrians at the Complex interchanges
- Pedestrian loading options
  - At-grade loading
  - Elevated structure
- Custom software programming
- Pedestrian walkway opened in 2021

Visualization of Elevated Passenger Loading
Source: Washington State DOT and CH2MHill 2011

Summary of Key Findings

- Use by all 49 responding DOTs
- Wide range of applications
  - Most used: signal retiming analyses
  - Initial scoping meetings
- Use of guidance
  - 21 DOTs developed guidelines
  - Ad-hoc project-based decisions
  - 2004 and 2019 TAT
- Most used resolution: microscopic
- Various software packages used
  - Most used: SimTraffic and Vissim
- Data sources
  - Traffic counts
  - Field observations
  - Aerial imagery
  - Online map data
- Use of checklists (11 DOTs)
- Reviews of performance measures
- Wide range of MOEs
- Use of animation
- Most simulation models developed by consultants
- Challenges
  - Data availability
  - Cost
  - Training needs
  - Demonstrating return on investment
- Opportunities
  - Ensuring consistency
  - Multimodal applications
  - 2019 TAT
  - Increasing use of MRM

Suggestions for Future Research

- Guidance on impact of new calibration and data collection recommendations (TAT 2004 vs. 2019)
- TSSM development and publication
- Guidance on data maintenance and archival
- Benefits of operational traffic simulation models
- Guidance/case examples for use of operational simulation models for safety analyses
- Case examples on use by MPOs and local agencies
- Case examples on post construction validation
- Development of reviewer training materials
- Guidance for use of A/I in calibration
- Guidance on data fusion
- Peer exchange
- Guidance on incorporating vulnerable road users (VRUs) into simulation modeling

Acknowledgements

- Research funded by NCHRP (Project Manager: Arefeh Nasri)
- DOTs who completed survey and participated in interviews
- Topic Panel
  - Ryan Hale, Missouri DOT
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  - Chris Melson, Oregon DOT
  - Eric Thomas, North Carolina DOT
  - Jongsun Won, FHWA Liaison
  - Cynthia Jones, TRB Liaison

References

- Alexiadis, V., K. Jeannotte, and A. Chandra, *Traffic Analysis Toolbox Volume I: Traffic Analysis Tools Primer*, Report No. FHWA-HRT-04-038, Federal Highway Administration, Washington, D.C., 2004.
- Baclet, S., K. Kaveh, P. Mozhgan, R. Romain, and H. Amnir, "Near-Real-Time Dynamic Noise Mapping and Exposure Assessment Using Calibrated Microscopic Traffic Simulations," *Transportation Research Part D: Transport and Environment*, Vol. 124, 2023, p. 103922.
- Chang, Y., and P. Edara, "Evaluation of a Reservation-Based Intersection Control Algorithm for Hurricane Evacuation with Autonomous Vehicles," *International Journal of Disaster Risk Reduction*, Vol. 31, 2018, pp. 1152–1158.
- Colorado DOT, *Traffic Analysis and Forecasting Guidelines*, Colorado Department of Transportation, Denver, Colorado, 2023.
- Creasey, F.T., and J. Choi, *Case Studies to Develop a Highway-Rail Grade Crossing Analysis Framework Using Microsimulation*, Federal Railroad Administration, Washington, D.C., 2023.
- Dowling, R., A. Skabardonis, and V. Alexiadis, *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*, Report No. FHWA-HRT-04-040, Federal Highway Administration, Washington, D.C., 2004.
- Georgia Transportation Institute, "GDOT-VISSIM Reviewer Guidance Modules," 2021 [Online]. Available: https://gti.gatech.edu/content/gdot-vissim-reviewer-guidance-modules.
- Kentucky Transportation Cabinet, *KYTC Microsimulation Guidelines*, Frankfort, Kentucky, 2021.
- Kim, B., K. Heaslip, M. Aad, A. Fuentes, and N. Goodall, "Assessing the Impact of Automated and Connected Automated Vehicles on Virginia Freeways," *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2675, No. 9, 2021, pp. 870-884.

References

- Kodupuganti, S., and S. Pulugurtha, "Are Facilities to Support Alternative Modes Effective in Reducing Congestion?: Modeling the Effect of Heterogeneous Traffic Conditions on Vehicle Delay at Intersections," *Multimodal Transportation*, Vol. 2, No. 1, 2023, p. 100050.
- List, G., *Overview of the Transportation System Simulation Manual (TSSM)*, presentation slides, North Carolina Institute of Transportation Engineers, 2021.
- Liu, B., A. Molan, A. Pande, J. Howard, S. Alexander, and Z. Lou, "Microscopic Traffic Simulation as a Decision Support System for Road Diet and Tactical Urbanism Strategies," *Sustainability*, Vol. 13, No. 14, 2021, p. 8076.
- Naser, M., and S. Birst, *Mesoscopic Evacuation Modeling for Small- to Medium-Sized Metropolitan Areas*, Upper Great Plains Transportation Institute, Fargo, North Dakota, 2010.
- Texas DOT, *Traffic Safety and Analysis Procedures Manual*, Texas Department of Transportation, Austin, Texas, 2024.
- Virginia DOT, *Traffic Operations and Safety Analysis Manual (TOSAM) Version 2.0*, Virginia Department of Transportation, Richmond, Virginia, 2020a.
- Virginia DOT, *VDOT VISSIM User Guide*, Version 2.0, Virginia Department of Transportation, Richmond, Virginia, 2020b.
- Washington State DOT and CH2MHill, Simulating WSF Ferry Terminals in VISSIM and CORSIM, Presentation slides, Washington ITE Simulation Roundtable, Seattle, Washington, 2011.

References

- Wisconsin DOT, *Traffic Engineering, Operations, and Safety Manual*, Wisconsin Department of Transportation, Madison, Wisconsin, 2019.
- Wunderlich, K., M. Vasudevan, and P. Wang, *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software 2019 Update to the 2004 Version*, Report No. FHWA-HOP-18-036, Federal Highway Administration, Washington, D.C., 2019.
- Zhou, X., M. Hadi, and D. Hale, *Multiresolution Modeling for Traffic Analysis: State-of-Practice and Gap Analysis Report*, Report No. FHWA-HRT-21-082, Federal Highway Administration, Washington, D.C., 2021.

Questions

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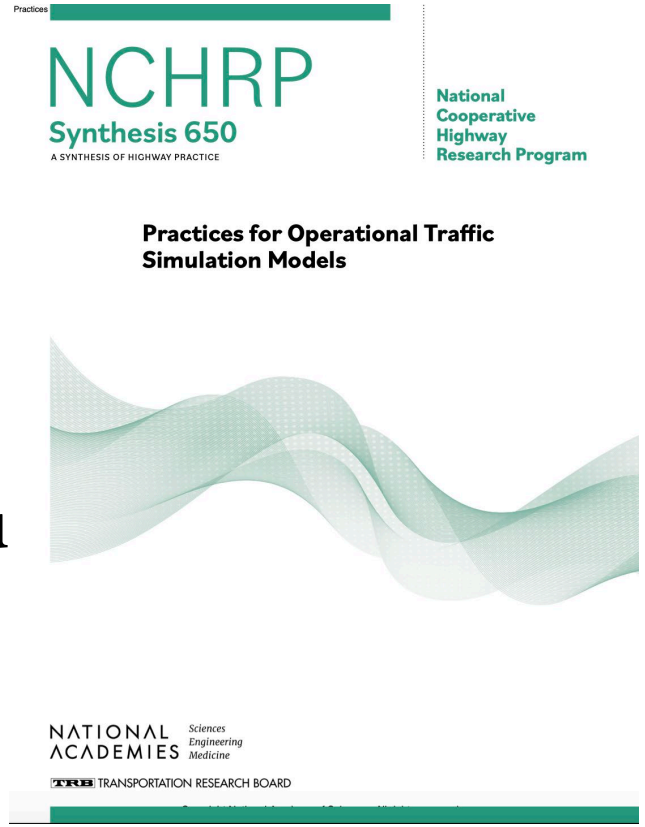

Thank you!

NCHRP Synthesis 650 Link:
https://doi.org/10.17226/29076

Balancing Precision & Pragmatism

Lessons Learned from the I-270 EIS Simulation Strategy

Rachel S. Ackermann, PE, ENV SP

FELSBURG HOLT & ULLEVIG
connecting & enhancing communities

Agenda

01	Project Background
02	Methodological Framework
03	Data & Analytical Framework
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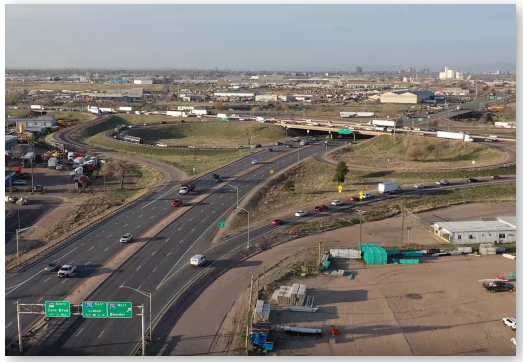
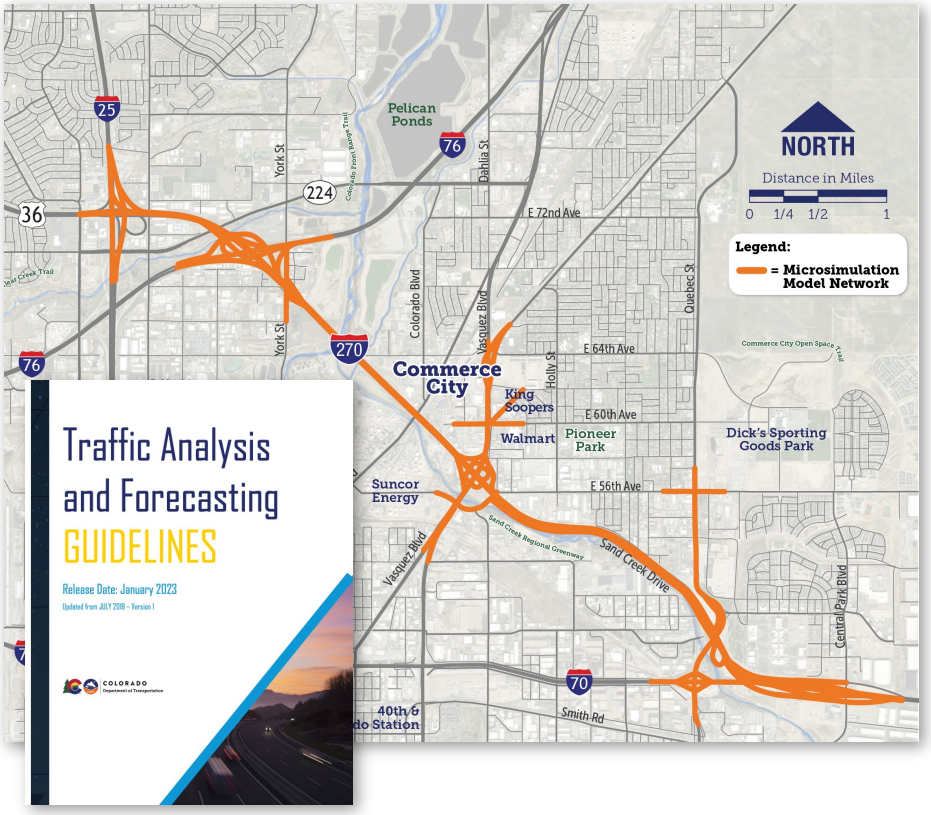
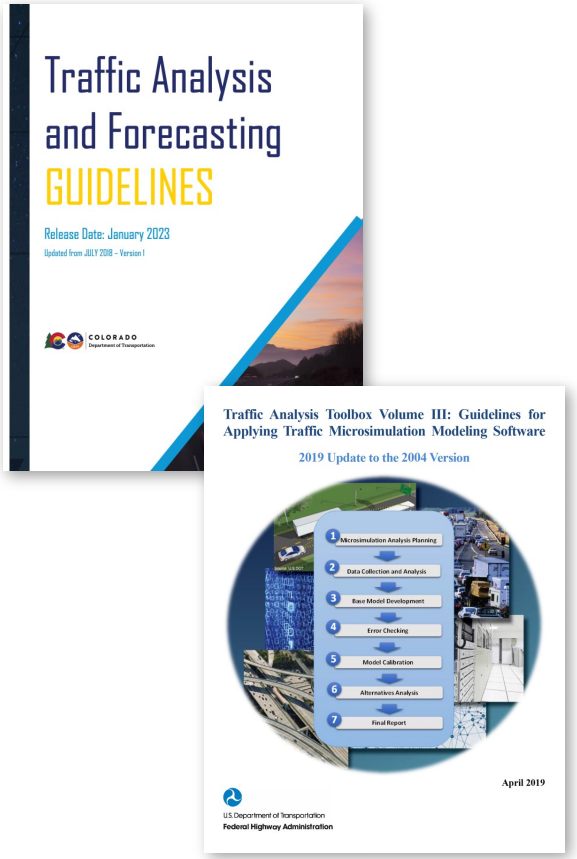


Project Background



Methodological Framework



- **2019 FHWA Traffic Analysis Toolbox (Vol. III)** introduced calibration goals to:
  - Encourage **comprehensive experimental design** across a range of travel conditions, not a single “average” day.
  - Emphasize **time-dynamic system performance** — capturing bottleneck formation and dissipation.
  - Establish a **data-driven, repeatable, and automatable** calibration process.
- **2023 CDOT Guidelines** adopted these FHWA methods statewide.
- **I-270 EIS**: first project in Colorado to operationalize the new approach under an active NEPA schedule.

Data & Analytical Foundation

- Comprehensive data inventory cross-checked short-duration counts vs ATR Selected datasets:
  - **INRIX travel times** – full coverage
  - **ATR volumes** – highest stability
  - **CDOT incident data**
  - **NWS weather data** (preferred over RWIS)
- Data segmented by direction and peak period (AM 6–10 / PM 4–7)

Calibration Framework & Hybrid Approach

01

Adopted **hybrid calibration approach** using available data

02

Calibrated to **dominant cluster** (most representative travel condition)

03

Applied **variation envelopes** where robust data existed

04

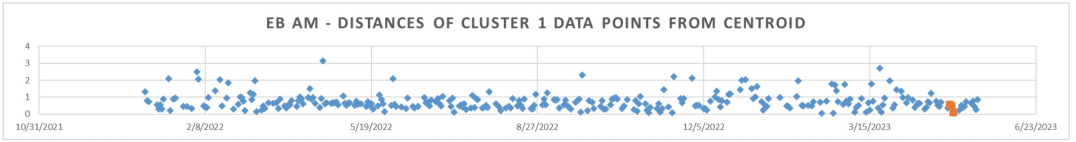
Combined multiple calibration criteria for flexibility

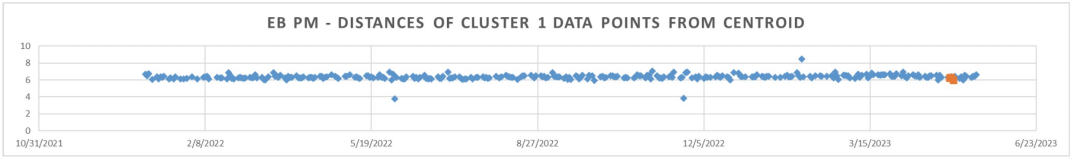
05

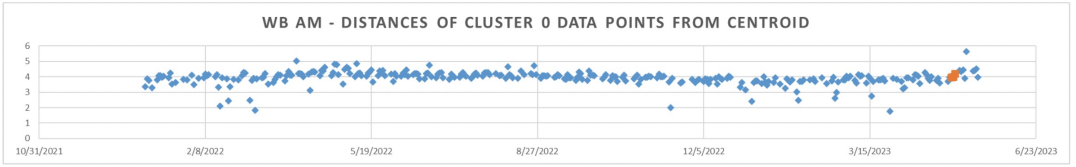
Maintained focus on **behavioral realism + statistical validity**

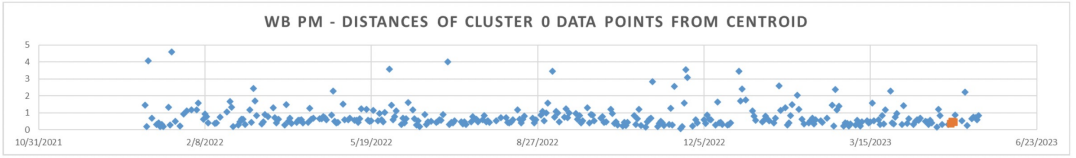
Cluster Analysis & Representative Day Selection

Model	Metrics	Cluster 0	Cluster 1	Cluster 2	Cluster 3
EB AM	Number of Days	24	301	26	
	Weather Days	4	15	18	
	Incidents Days	24	2	0	
	Max Severity	5	2	0	
	Avg Peak Volume	11237	12645	7820	
	Avg Max-Travel-Time_Segment (sec)	800	542	508	
	Assigned Category	Incident Cluster	Average Day	Weather Cluster	
EB PM	Number of Days	18	318	15	
	Weather	17	21	0	
	Number of Incidents	1	2	15	
	Max Severity	5	2	5	
	Avg Peak Volume	6619	9077	8285	
	Avg Max-Travel-Time_Segment (sec)	338	473	864	
	Assigned Category	Weather Cluster	Average Day	Incident Cluster	
WB AM	Number of Days	312	17	23	1
	Weather	21	1	16	0
	Number of Incidents	0	17	0	1
	Max Severity	0	6	0	5
	Avg Peak Volume	11505	10156	7034	10147
	Avg Max-Travel-Time_Segment (sec)	650	1312	398	803
	Assigned Category	Average Day	Incident Cluster	Weather Cluster	Incident with higher Duration
WB PM	Number of Days	320	16	15	2
	Weather	20	16	2	0
	Number of Incidents	1	0	14	2
	Max Severity	1	0	5	2
	Avg Peak Volume	9294	6976	8001	6886
	Avg Max-Travel-Time_Segment (sec)	1071	750	1451	2059
	Assigned Category	Average Day	Weather Cluster	Incident Cluster	Incident with higher Duration









Calibration Results & Model Performance

Table 4. Wisconsin DOT freeway model calibration criteria.

Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Within 400 veh/h, for Flow > 2700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows*	> 85% of cases
GEH Statistic for Sum of All Link Flows	GEH < 4 for sum of all link counts
Travel Times, Model Versus Observed	
Journey Times, Network	
Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Individual Link Speeds	
Visually Acceptable Speed-Flow Relationship	To analyst's satisfaction
Bottlenecks	
Visually Acceptable Queuing	To analyst's satisfaction

CRITERION I: 95% of simulated outputs fall within the ~2 Sigma Band, $c_r(t) \pm 1.96 \times \sigma(t)$. Note that if fewer than 20 time intervals are used to characterize time-dynamics, Criterion I is relaxed to allow for one simulated result outside the ~2 Sigma Band.

CRITERION II: Two-thirds of the simulated results (and both critical time intervals) fall within the 1 Sigma Band for this travel condition.

Criterion III: Bounded Dynamic Absolute Error (BDAE)

This criterion ensures that, on average, simulated results are close to the observed representative day. The criterion involves a test to ensure that the average simulated absolute error from the representative day over all time intervals is less than or equal to differences from the representative day seen across all days in the travel condition. Let:

$c_r(t)$	Observed value of representative day during time interval t
$c_i(t)$	Observed value of non-representative day within the cluster during time interval t
$\tilde{c}_r(t)$	Simulated performance measure during time interval t
N_T	Number of time intervals
$N_{cluster}$	Number of days in the cluster representing this travel condition

Next, calculate the BDAE Threshold:

$$\text{BDAE Threshold} = \frac{\sum_{i \neq r} \sum_t \frac{|c_r(t) - c_i(t)|}{N_T}}{N_{cluster} - 1} \qquad (12)$$

CRITERION III is met when:

$$\frac{\sum_t |c_r(t) - \tilde{c}_i(t)|}{N_T} \leq \text{BDAE Threshold} \qquad (13)$$

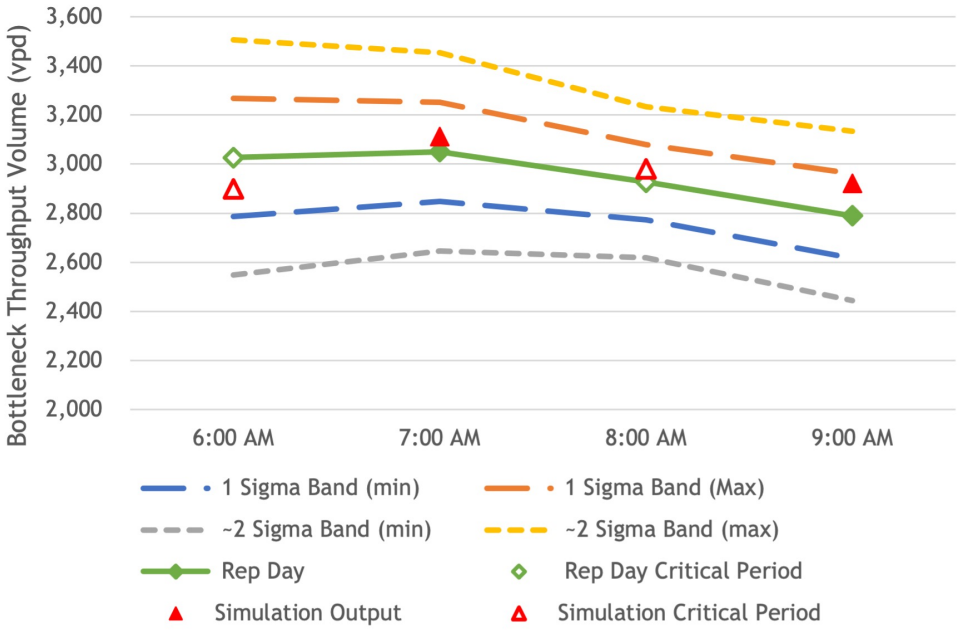
Criterion IV: Bounded Dynamic Systematic Error

This criterion ensures that the simulated data are not excessive over- or under-estimators. In this case, the criterion utilizes a similar test to Criterion III but with respect to average simulated error (not absolute).

CRITERION IV is met when:

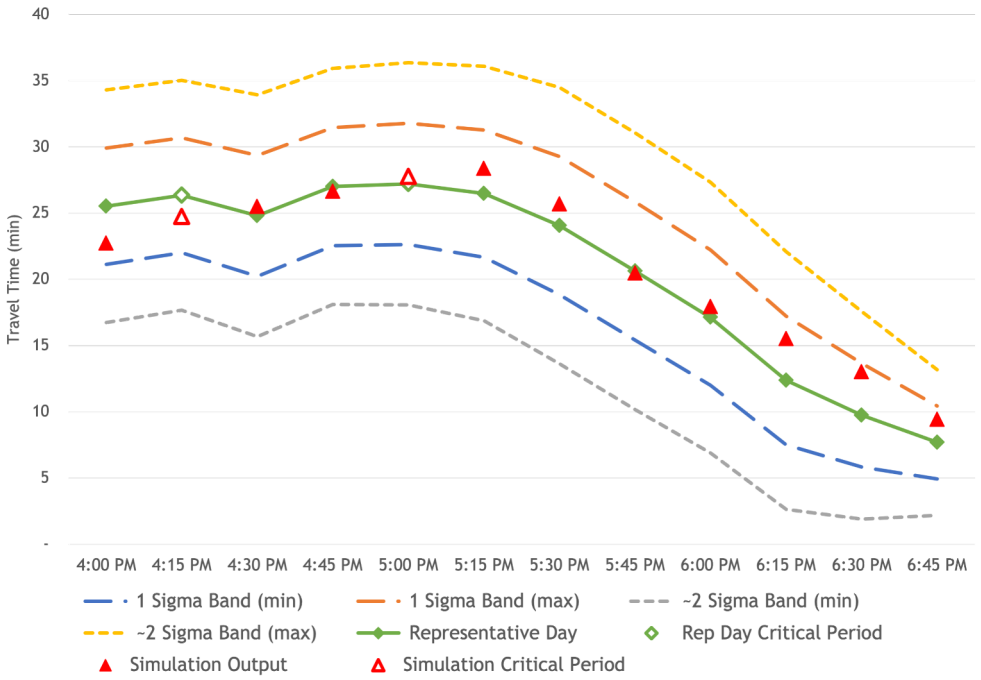
$$\left| \frac{\sum_t c_r(t) - \tilde{c}_i(t)}{N_T} \right| \leq \frac{1}{3} \times \text{BDAE Threshold} \qquad (14)$$

Calibration Results & Model Performance



CRITERION I: 95% of simulated outputs fall within the ~2 Sigma Band. Note: If fewer than 20 time intervals are used to characterize time-dynamics, Criterion I is relaxed to allow for one simulated result outside the ~2 Sigma Band.				
Number of Intervals within the ~2 Sigma Band:		4/4	100%	PASS
CRITERION II: Two-thirds of the simulated results (and both critical time intervals) fall within the 1 Sigma Band for this travel condition.				
Number of Intervals within the 1 Sigma Band:		4/4	100%	PASS
Number of Critical Time Intervals within the 1 Sigma Band:		2/2	100%	PASS
CRITERION III: $\frac{\sum_t \lvert c_r(t)-\tilde{c}_i(t)\rvert}{N_T} \leq BDAE\ Threshold$				
$\frac{\sum_t \lvert c_r(t)-\tilde{c}_i(t)\rvert}{N_T}$:	94	BDAE Threshold:	130	PASS
CRITERION IV: $\left\lvert\frac{\sum_t c_r(t)-\tilde{c}_i(t)}{N_T}\right\rvert \leq \frac{1}{3} \times BDAE\ Threshold$				
$\left\lvert\frac{\sum_t c_r(t)-\tilde{c}_i(t)}{N_T}\right\rvert$:	30	$\frac{1}{3} \times BDAE\ Threshold$:	43	PASS

Calibration Results & Model Performance



CRITERION I: 95% of simulated outputs fall within the ~2 Sigma Band. Note: If fewer than 20 time intervals are used to characterize time-dynamics, Criterion I is relaxed to allow for one simulated result outside the ~2 Sigma Band.			
Number of Intervals within the ~2 Sigma Band:	12/12	100%	PASS
CRITERION II: Two-thirds of the simulated results (and both critical time intervals) fall within the 1 Sigma Band for this travel condition.			
Number of Intervals within the 1 Sigma Band:	12/12	100%	PASS
Number of Critical Time Intervals within the 1 Sigma Band:	2/2	100%	PASS

CRITERION III: $\frac{\sum_t \lvert c_r(t)-\tilde{c}_i(t)\rvert}{N_T} \leq$ ***BDAE Threshold***				
$\frac{\sum_t \lvert c_r(t)-\tilde{c}_i(t)\rvert}{N_T}$:	1.55	BDAE Threshold:	4.31	PASS
CRITERION IV: $\left\lvert\frac{\sum_t c_r(t)-\tilde{c}_i(t)}{N_T}\right\rvert \leq \frac{1}{3} \times BDAE\ Threshold$				
$\left\lvert\frac{\sum_t c_r(t)-\tilde{c}_i(t)}{N_T}\right\rvert$:	0.73	$\frac{1}{3} \times BDAE\ Threshold$:	1.44	PASS

Implementation & Collaboration

- **Strong coordination** among FHU, CDOT & FHWA
- Shared understanding of guidance timing, data limits, and schedule
- Cross-department data integration
- Continuous review reduced rework and improved model acceptance
- Model met all agreed upon **FHWA calibration acceptance thresholds**

Lessons Learned & Broader Implications

- Data sufficiency dictates calibration ambition
- Collaboration enables defensible flexibility
- Cluster analysis improves transparency and replicability
- Hybrid calibration allowed the project to maintain credibility and meet requirements under constraints
- Approach now informing future CDOT modeling practice

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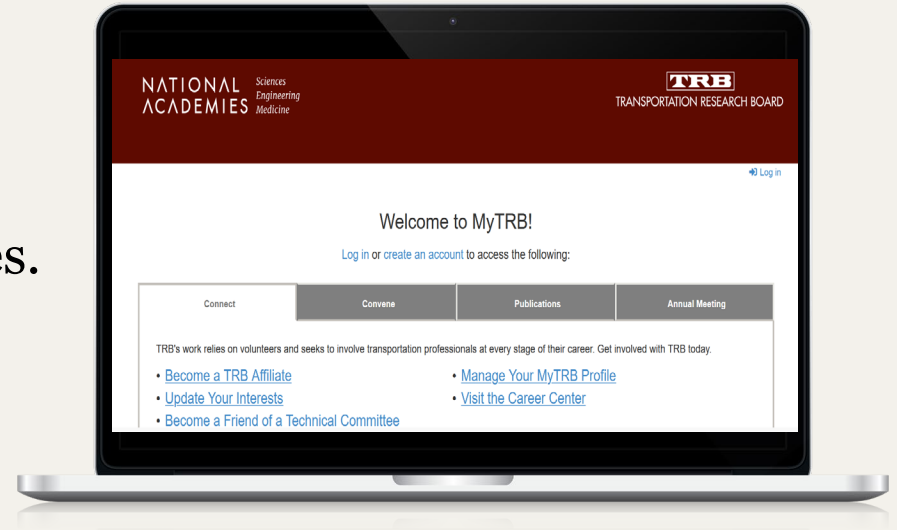

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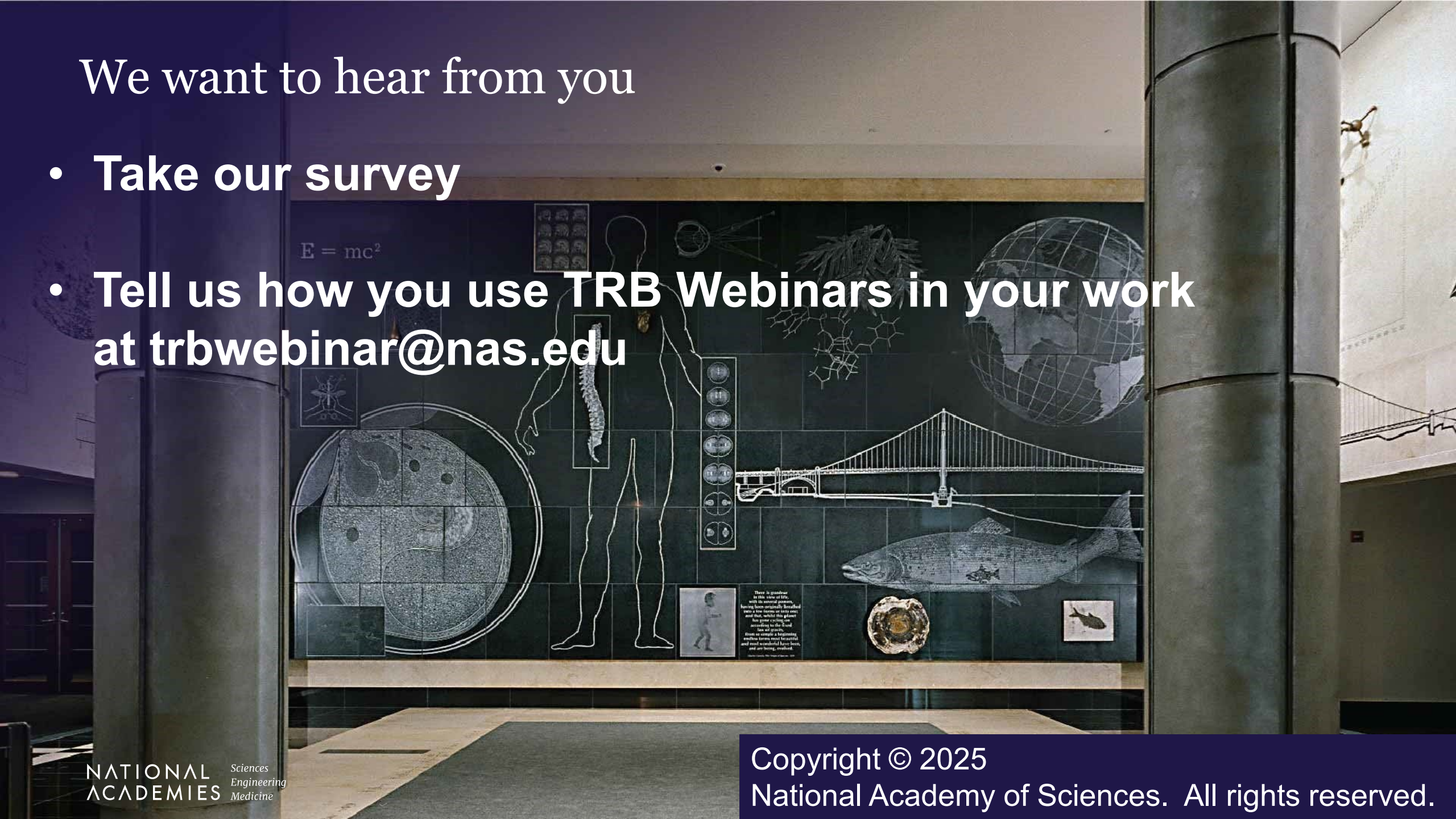

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