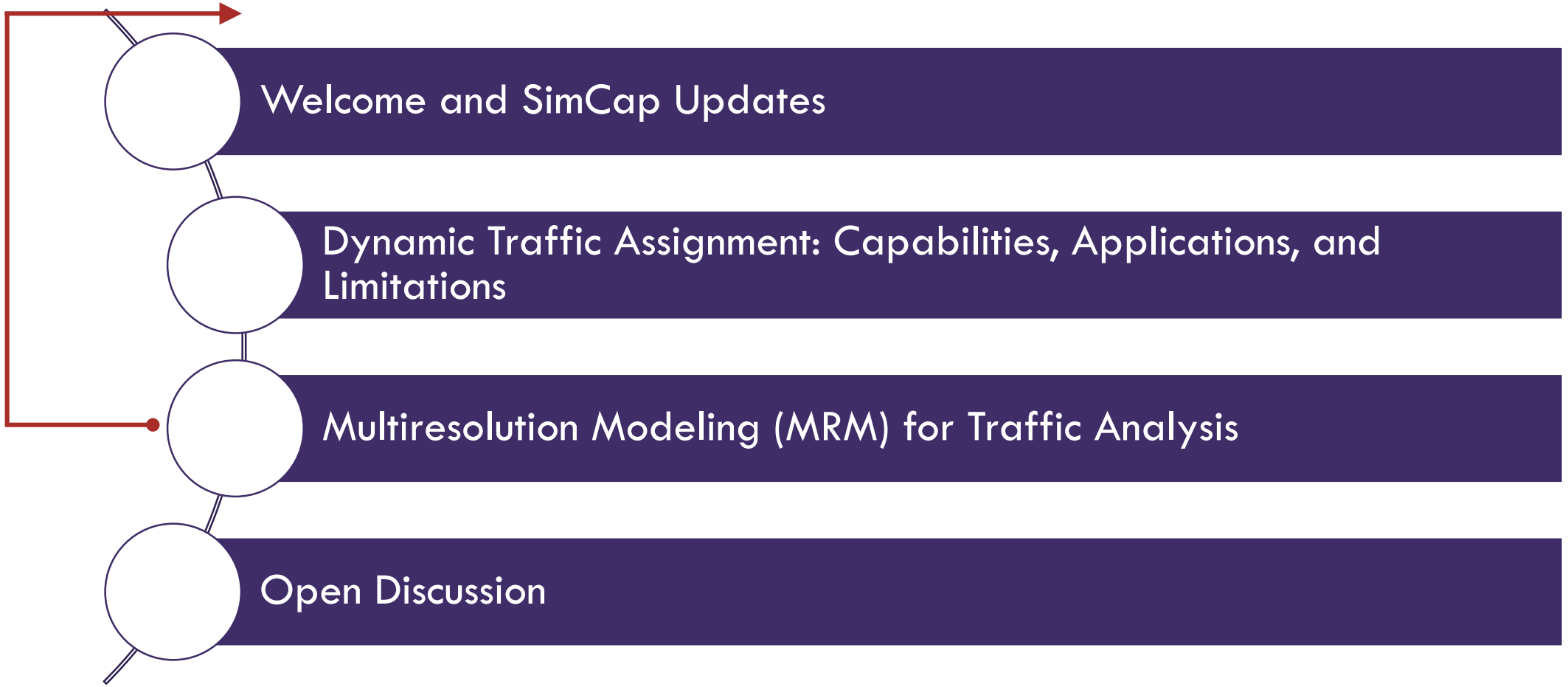
Volunteer Network of Professionals Working Together to Support, Promote, and Improve Best Practices in the Application of Traffic Simulation and Capacity Analysis

9/09/2020

Educational Meeting #6

Meeting Agenda



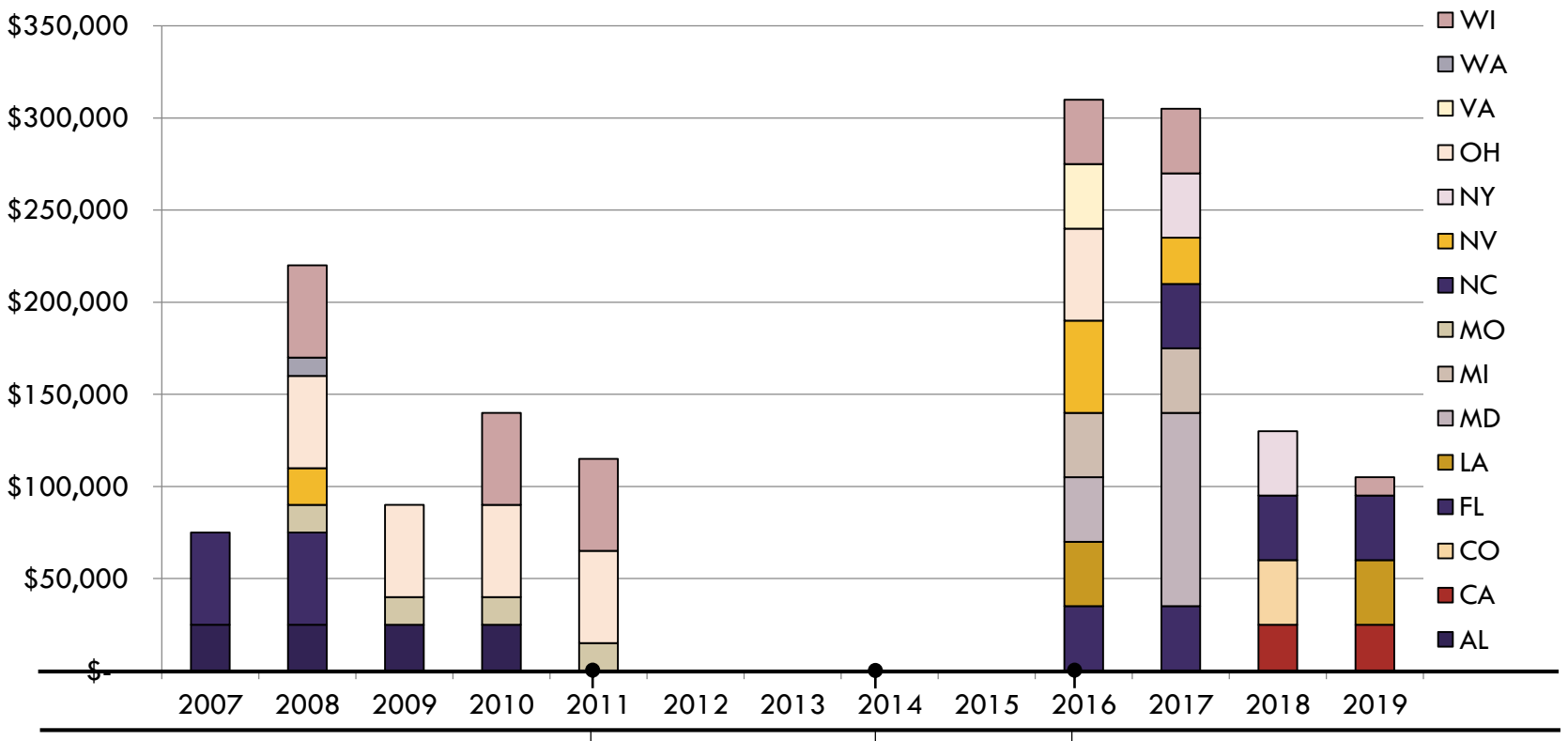
ITE SimCap Committee

- Held Annual Meeting (8/19)
  - Materials posted to SimCap e-Community
- Initiative to establish ITE website
  - Feedback solicited on initial structure/content
- Initiative to establish repository of SimCap-related user groups
  - Contact Eric Tripi (Eric.Tripi@ghd.com) or Chris Melson (cmelson1@lsu.edu)

TRB Standing Committee on Traffic Simulation

- Newly established TRB Committee (ACP80)
  - More information at TRB and their website
- Workshop on Traffic Simulation and Connected and Automated Vehicle Modeling (11/16-11/18)
  - Virtual format

TPF-5(176) – Traffic Analysis and Simulation



Guide on the Consistent Application of Traffic Analysis Tools and Methods

Guidance on the Level of Effort Required to Conduct Traffic Analysis Using Microsimulation

Chapters 23 and 24 of *Highway Capacity Manual (HCM) 6th Edition*

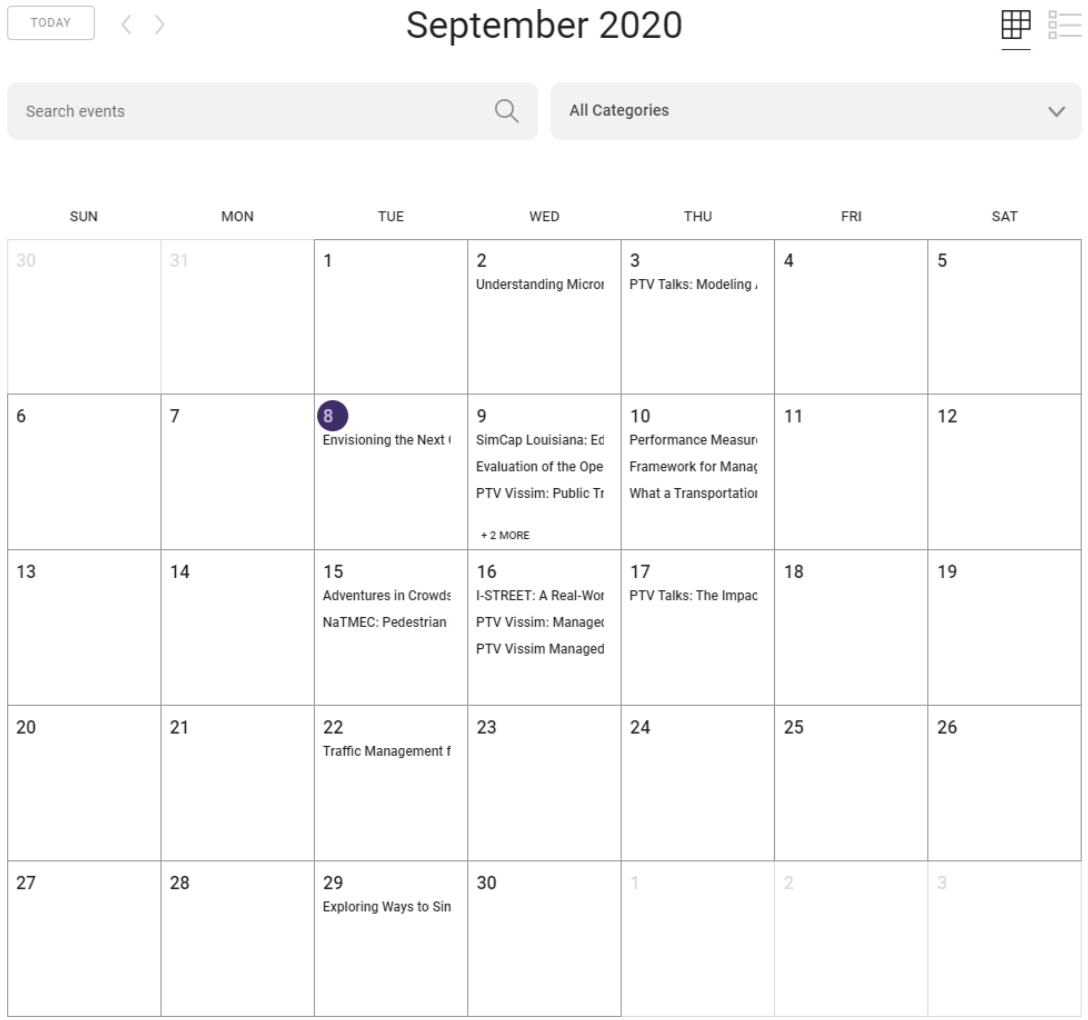
Transportation System Simulation Manual (TSSM)

Trajectory Investigation for Enhanced Microsimulation Calibration Guidance

Multi-Resolution Modeling for Traffic Analysis

SimCap Louisiana

- https://simcap.eng.lsu.edu/
  - Past/upcoming activities
  - Calendar of SimCap events
  - Meeting archive
    - Password: **simcap** (lowercase, no spaces)



Mohammed Hadi
Florida International University

David Hale
Leidos

Source: FHWA.

Source: FHWA.

Source: FHWA.

Source: FHWA.

Multiresolution Modeling (MRM) for Traffic Analysis

Presented at the SimCap Louisiana
Educational Meeting #6
September, 2020

David Hale
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Leidos

Xuesong (Simon) Zhou
Principal Investigator
Arizona State University

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Federal Highway Administration (FHWA)

U.S. Department of Transportation
Federal Highway Administration

SAXTON LABORATORY

Project Objectives

- Comprehensively assess the current state of the practice of MRM in transportation analyses.
- Evaluate and assess gaps preventing the adoption of MRM by agencies.
- Develop a software-agnostic guidebook to assist agencies with developing a fully integrated MRM model.
- Illustrate the benefits of applying MRM in two case studies.

Project Overview and Understanding

- Analysis, modeling, and simulation (AMS) tools are increasingly vital to design and manage complex systems.
- The AMS tools exist at multiple resolutions, each having specific advantages and disadvantages.
  - Primary options: macroscopic, mesoscopic, microscopic.
- Researchers and developers are now advocating for wider use of multiresolution modeling (MRM).
  - Richer output information, better identification of modeling errors, better understanding of interacting factors that influence traffic.
  - Increased requirements: time, funds, expertise, data, license fees.

Project Overview (Continued)

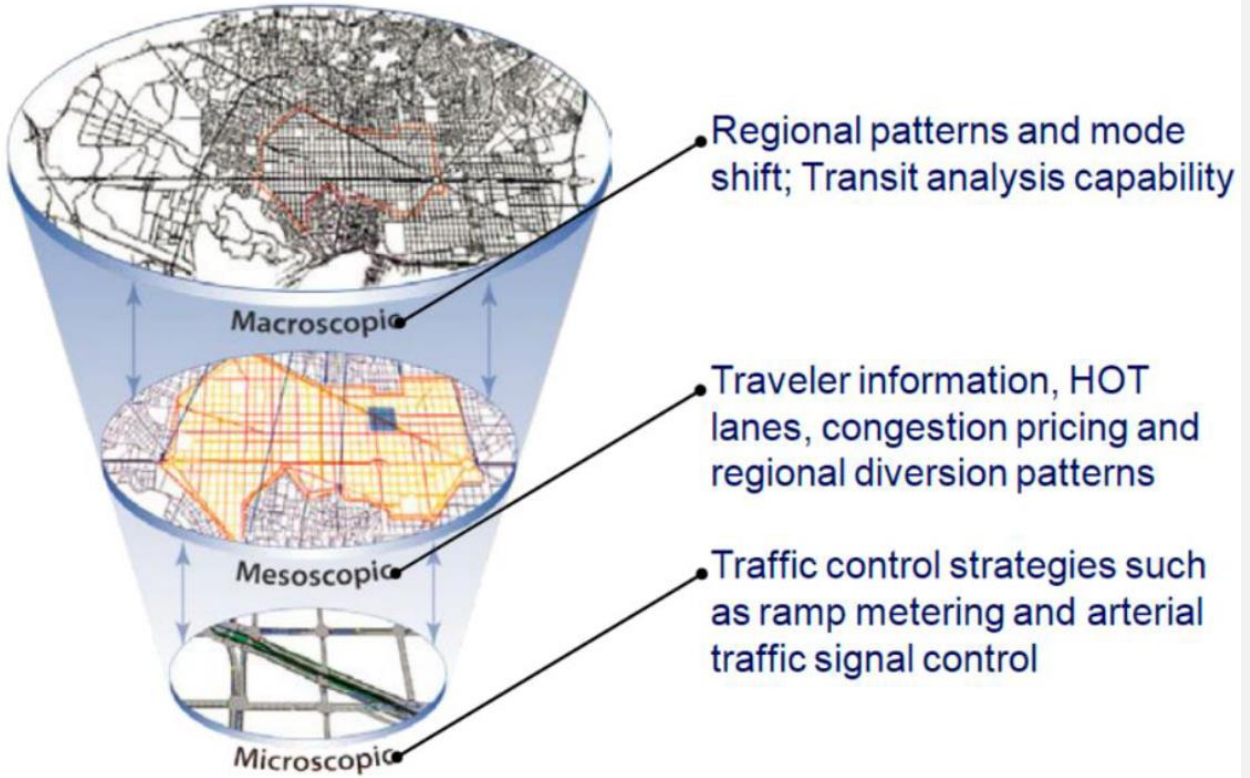

Figure 1: AMS tool resolutions (Source: FHWA Traffic Analysis Toolbox)

HOT = High Occupancy Toll

Project Objectives

- Comprehensively assess the current state of practice of MRM in transportation analyses.
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- Illustrate the benefits of applying MRM in two case studies.

Task 3: State-of-the-Practice Report—High-Level Outline

- Terminology and definitions.
- Review of tools.
- Review of literature.
- Industry feedback.

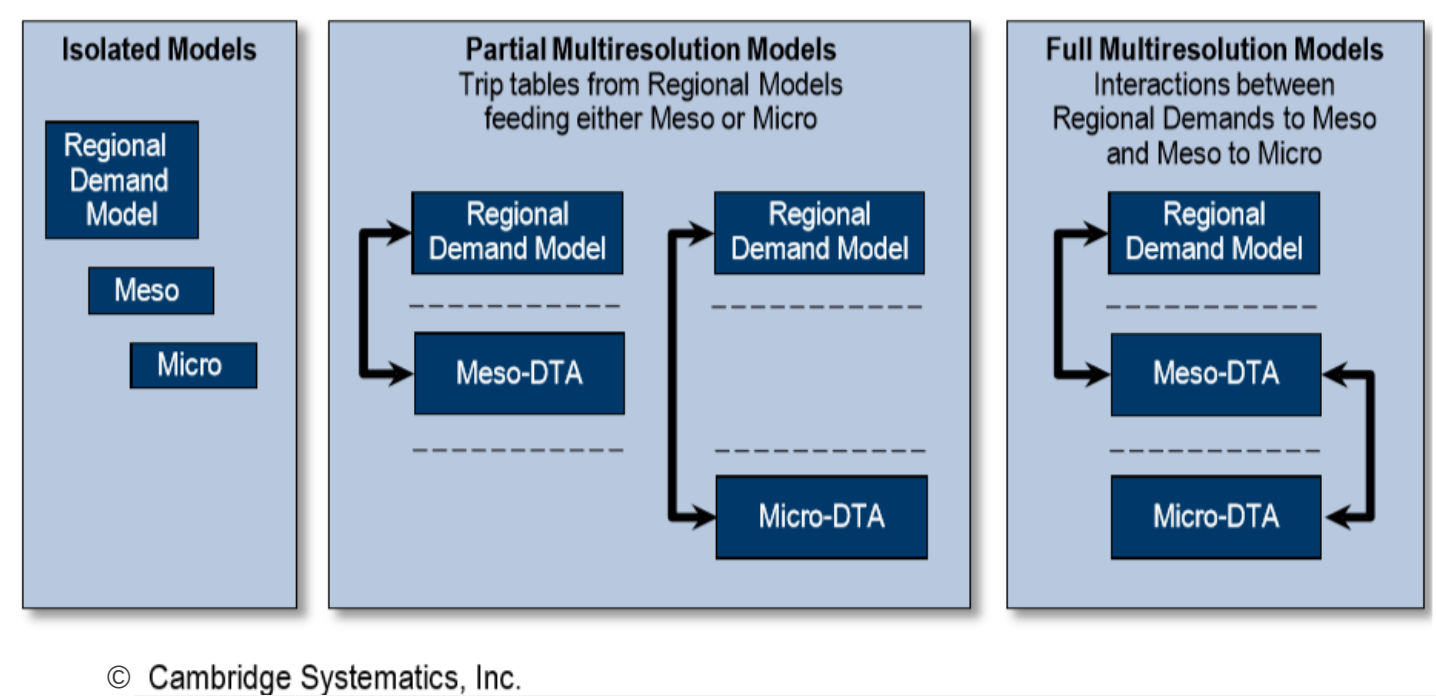
Task 3: Definition of MRM

- Multiple resolutions of modeling tools used to answer one or more questions.
- Integration of models with different spatial and temporal resolutions.
  - Temporal resolution conveys how often the model is updated.
  - Spatial resolution refers to the size of physical network elements used in the model.
- MRM methodologies encompass[1]:
  - Determination of macroscopic trip patterns and potentially land-use patterns.
  - Mesoscopic analyses of changes in strategic driver behavior in reaction to congestion patterns and mitigation strategies.
  - Microscopic analyses of traffic flow and management strategy impacts.

[1]Source: Traffic Analysis Toolbox Volume XIV: https://ops.fhwa.dot.gov/publications/fhwahop13015/index.htm

Task 3: Definition of Partial MRM

Trip tables from regional demand models are exported to mesoscopic and microscopic dynamic traffic assignment (DTA).



Task 3: Definition of Hybrid Simulation

- Online or run-time integration of microscopic and mesoscopic models.
- A subarea typically runs with microscopic logic, while the rest of the network runs with mesoscopic logic.
- Mesoscopic and microscopic domains are typically predefined, and vehicles in both regions are simulated concurrently.[1]

[1]Source: Traffic Analysis Toolbox Volume XIV: https://ops.fhwa.dot.gov/publications/fhwahop13015/index.htm

Task 3: (State-of-the-Practice Report) Literature Review

- Guidelines, pilots, and proofs of concept.
- Feasibility and benefits of MRM.
- Consistency of MRM.
- Developments to support MRM and hybrid modeling.
- Applications of multiresolution and hybrid modeling.

Task 3: State-of-the-Practice Literature Summary

- Benefits:
  - Assessment of regional impacts of a change in behavior.
  - Reuse for projects; reuse as a data source.
  - Data sharing.
- Challenges:
  - Data availability.
  - Budget and resources.
  - Limited understanding of consistency.

Task 3: (State-of-the-Practice Report) Outreach

- Conducted thirteen web conferences:
  - Nine practitioners and four developers.
- Assembled preliminary findings (trends):
  - Software features.
  - Common practices.
  - Computer capabilities.
  - Convergence and feedback.

Task 3: Industry Discussion Topics

- How do you define MRM?
- How many MRM projects have you conducted, are involved in, or know of in your State/region?
- How have you implemented MRM?
- How much effort does it takes to set up an MRM?
- What are the limits of your MRM size?
- What are the benefits and costs of MRM?
- What are the barriers to applying MRM?
- What defines your hesitation to apply MRM?
- What is your agency's interest level in MRM?
- What will be the short-term and long-term impacts of MRM?

Task 3: Vendor Discussion Topics

- How do you define MRM?
- What MRM advertising do you have?
- How important do you think MRM is?
- What MRM case studies do you have?
- What MRM features (e.g., feedback, convergence) do you currently offer?
- What is your company's interest level in MRM?
- What MRM features are you planning to develop?
- What interest level in MRM do you perceive from your customers?
- Can you provide any documentation or guidance related to MRM models in your tools and the implementation of these models?

Task 3: State-of-the-Practice Feedback Summary

Regional macro → subarea macro → meso → subarea micro → micro.

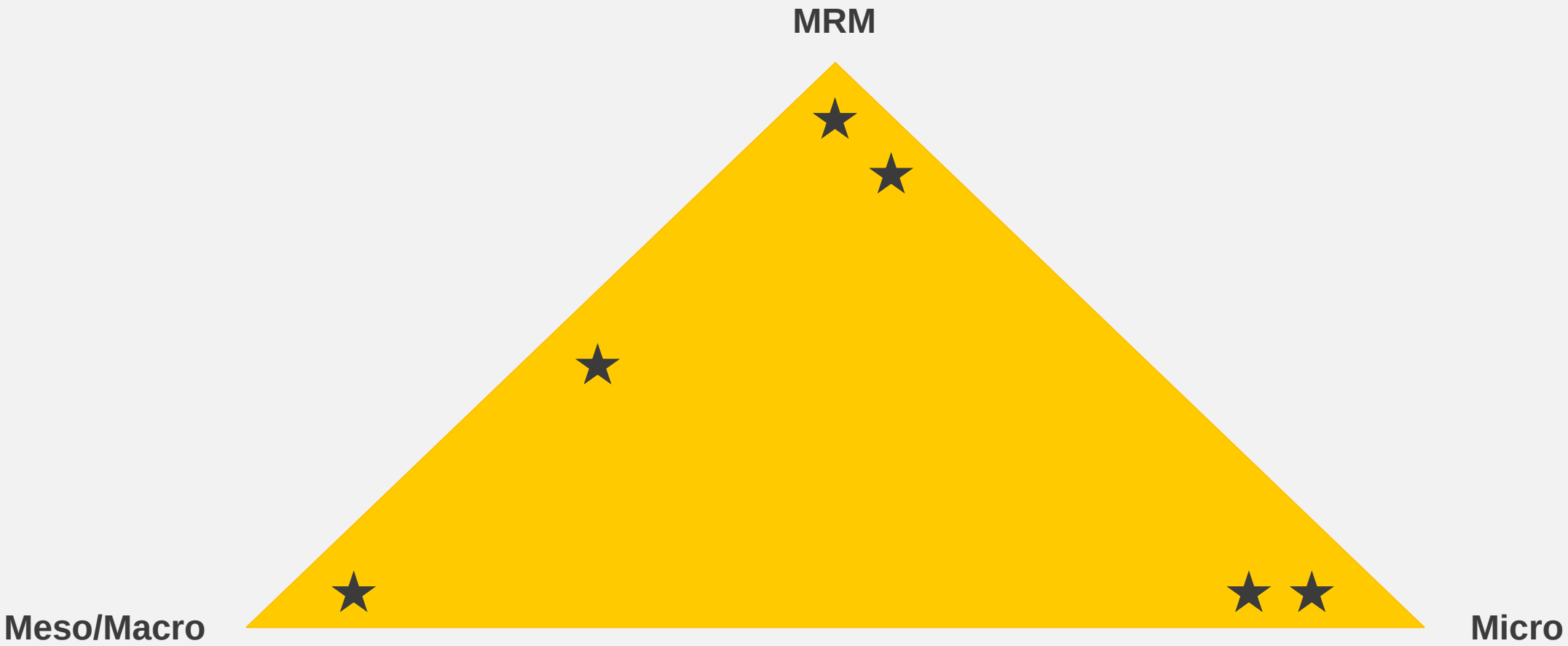
Activity-based model plus dynamic traffic assignment → subarea micro.

- Less common is feedback to the upper level; hybrid simulation.
- Interest in MRM is increasing very slowly (inertia).
- Publicity for MRM success stories could be helpful.
- MRM tools can still be improved.
- MRM can make analysis results more defendable.

Task 3: State-of-the-Practice Feedback Summary (continued)

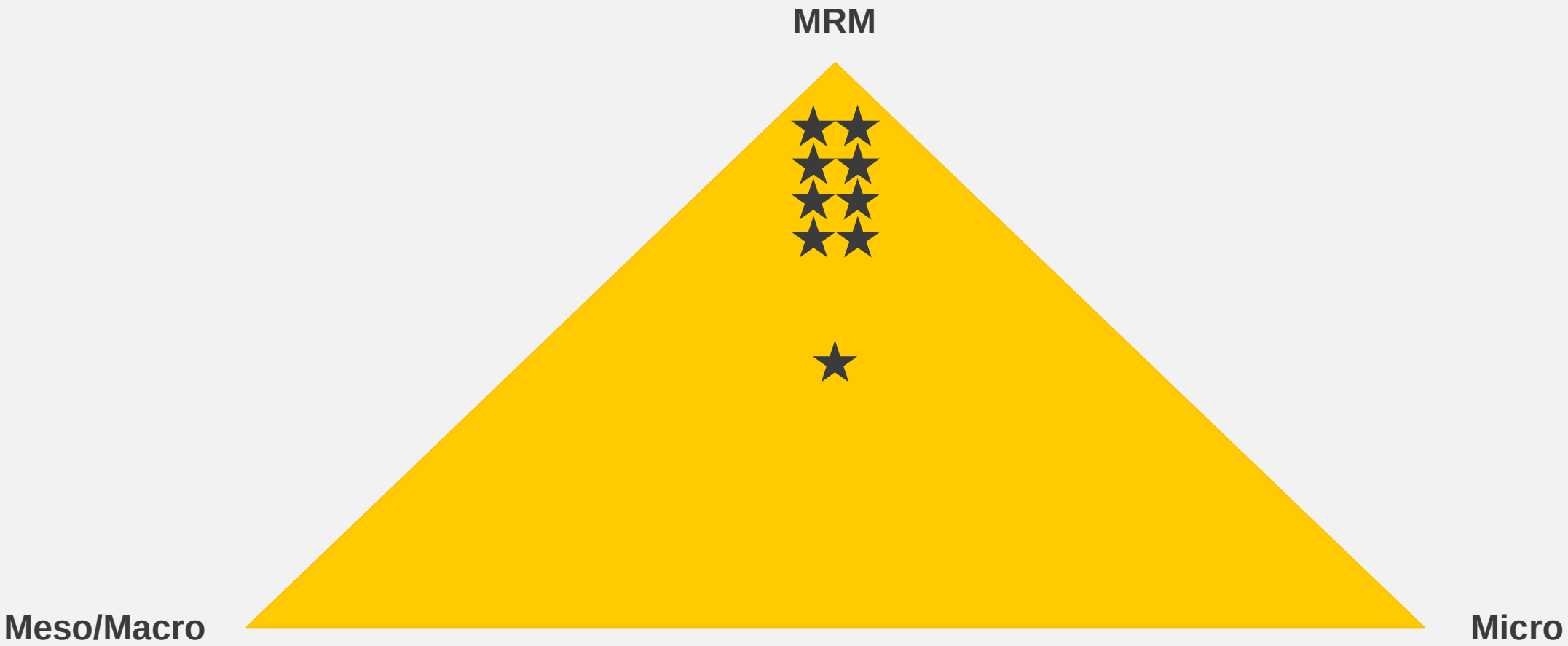
- Follow-on questions to the vendors:
  - What features exist for feedback and convergence?
  - What are the boundary conditions for hybrid modeling?

Task 3: State-of-the-Practice Vendor Viewpoint



Source: FHWA.

Task 3: State-of-the-Practice Practitioner Viewpoint



Source: FHWA.

Task 4: Gap Analysis

- Five (5) web conferences conducted in May and June 2020.
- Sample topics discussed:
  - What types of traffic modeling do you commonly perform?
  - What is your agency's interest level in MRM?
  - What are the benefits and costs of MRM?
  - What are the barriers to applying MRM?
  - What defines your hesitation to apply MRM?
  - Do you have the resources, funds, and expertise for MRM?
  - Do your business processes include simulation and/or MRM?
  - What performance measures and features do you need?
  - What additional data sources do you need?

Gap Analysis Feedback Summary

- Reasons to avoid MRM:
  - Start-up costs.
  - Learning curves.
  - Insufficient guidance.
  - Tools not well integrated.
  - Functions not well automated.
  - Few success stories or pilot projects.
  - Uncertainty about cost-effectiveness.
  - Current analyses not being challenged.
  - Little need for large spatiotemporal scopes.

Barriers

Incentives

Gap Analysis Framework

- Compare current and needed capabilities to identify gaps.
- Utilize dimensions of the Capability Maturity Model (CMM) framework used for self-assessment of Transportation Systems Management and Operations (TSMO) programs.
- Six dimensions of the TSMO CMM framework: Business processes, performance measurement, systems and technology, culture, organization and workforce, collaboration.
- The purpose is not to develop an MRM CMM, but to use the six dimensions to guide the gap analysis.

Process and Institutional Dimensions

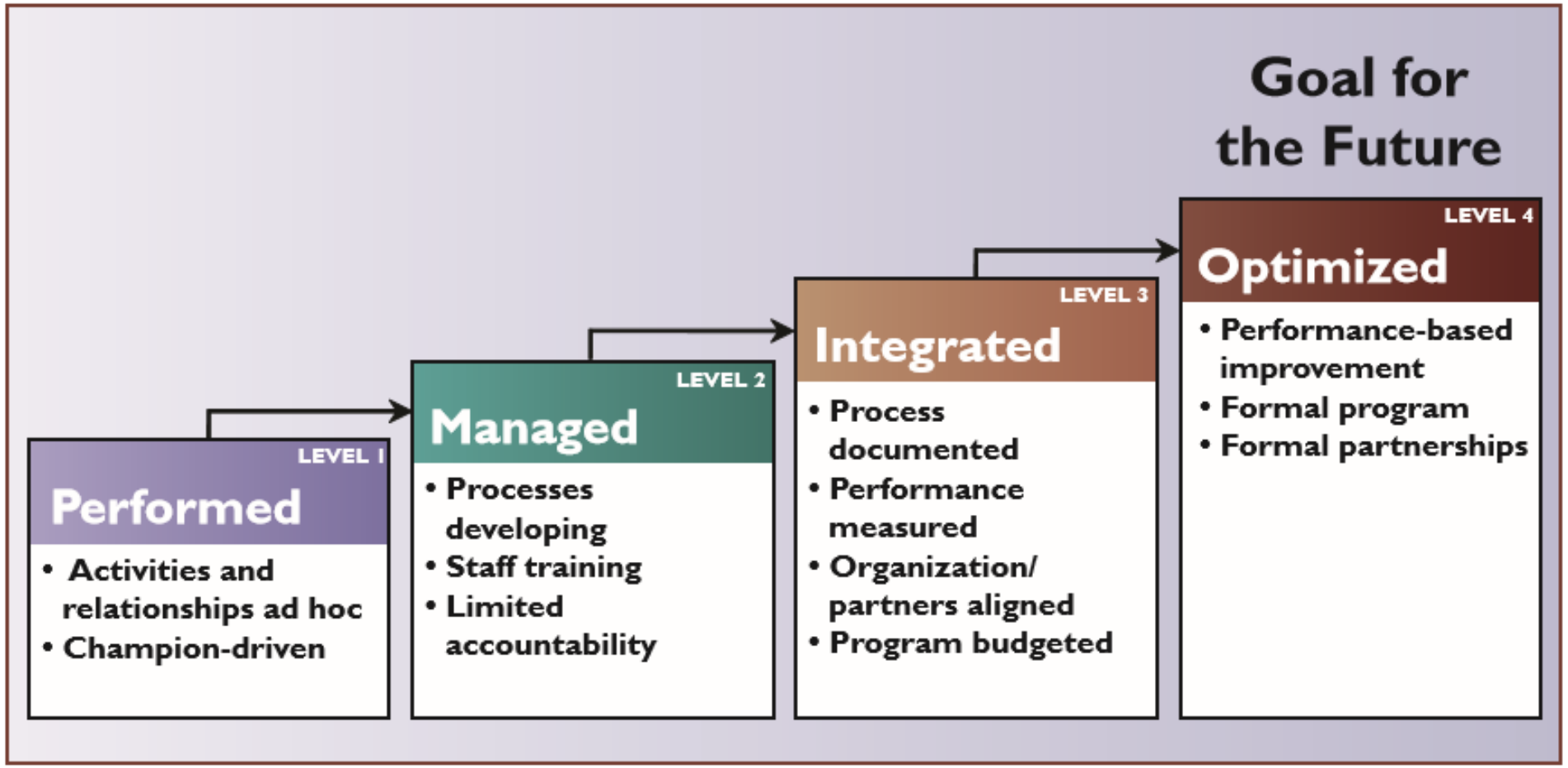
"Capabilities"

Business and technical processes support strategies

Organization and relationships support processes

Source: FHWA.

Generic Levels of Capability Maturity



Source: FHWA, "Creating an Effective Program to Advance Transportation System Management and Operations - Primer," January 2012

Business Processes

- Training.
- Contracting and Procurement.
- Model Archiving and Maintenance.
- Budget and Time Requirements/Justification.
- Institutionalization and Provision of Guidance.

Performance Measurements

- Performance Measure Definitions - Need to Ensure Consistency.
- Additional Performance Measure Assessment: Reliability, emissions, safety.
- Data needs.
- Consistency in performance measure calculation.

Systems and Technologies

- Integration and Data Conversion Tools.
- MRM Tools.
- Multimodal Modeling.
- Peak Spreading and Contracting.
- Signal Control Modeling.
- Modeling of Emerging Technologies.
- Feedback Loop.
- Setting the Model Limits.

Organization and Workforce

- Staffing/Lack of Experience Background.
- Staff Retention Issues/Retirements.
- Training.

Collaboration and Culture

- Collaboration:
  - Inter- and intra-agency collaboration.
  - Role of consultant.
- Culture:
  - Understanding the tools.
  - Understanding the benefits.
  - Need for lessons learned/incremental credibility.
  - Lack of messaging.

Task 6: Case Study and Benefits Quantification

Plans underway for two MRM case studies.

- Determine regional emphasis in Arizona/Maryland study.
- Determine subarea emphasis in Florida study.
- Have both new studies include all three levels (macro, meso, micro).
- Pursue circular data feedback to converge at one solution.
- Provide step-by-step details of how the MRM was conducted.
- Estimate MRM benefits and costs.

Interactive Session

Questions, comments, or suggestions?

Disclaimer

The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this presentation only because they are considered essential to the objective of the presentation. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

SAXTON LABORATORY

Questions?

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Source: FHWA.

INRO

Michael Mahut
INRO

Dynamic Traffic Assignment: Capabilities, Applications, Limitations

Michael Mahut, VP Simulation, INRO
michaelm@inrosoftware.com

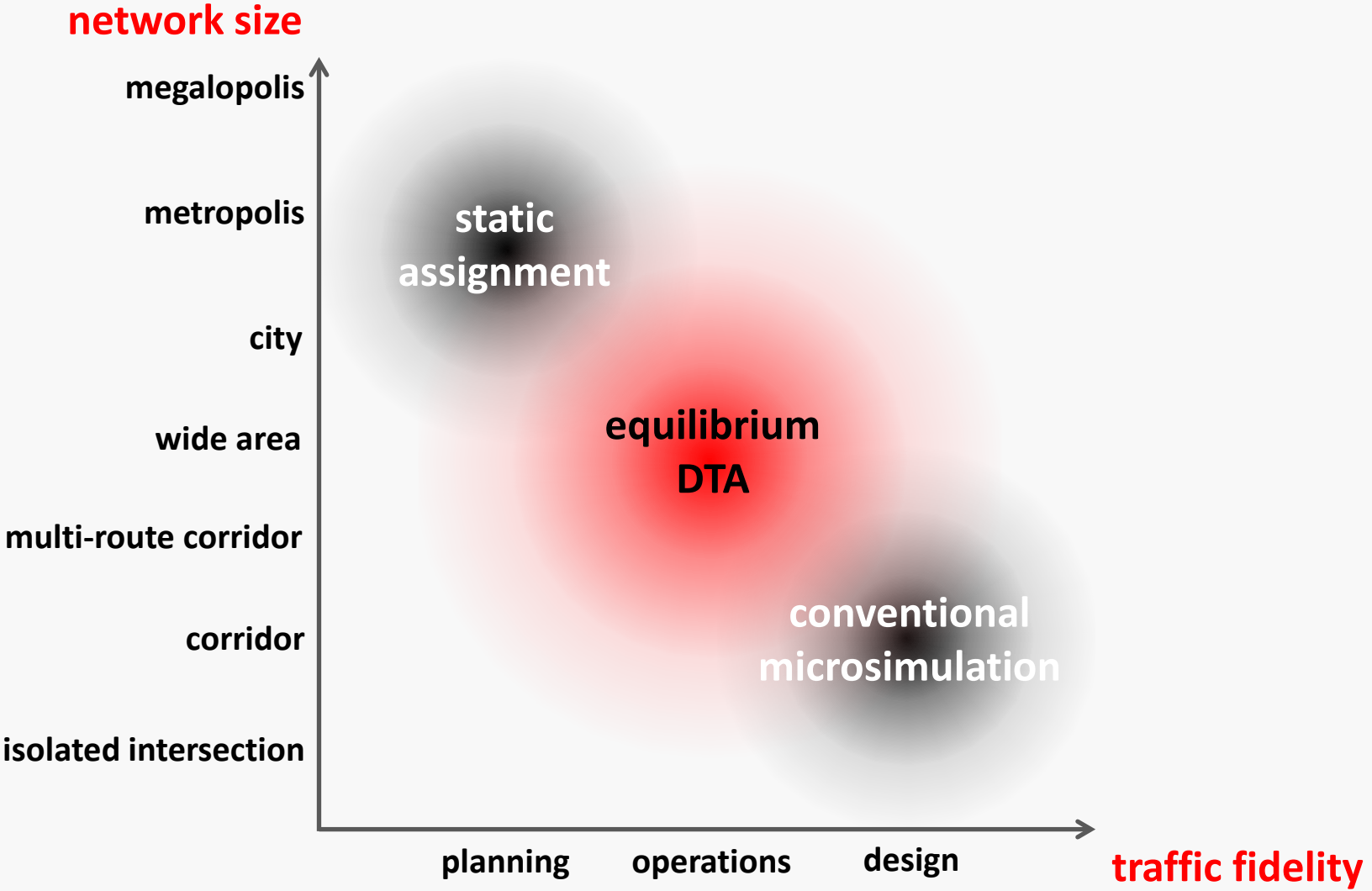
Simulation and Capacity Analysis User Group – Louisiana
Educational Meeting #6 - Sept 10, 2020

INRO

Overview of Dynamic Traffic Assignment

What is Dynamic Traffic Assignment?

- Time-dependent (“dynamic”) model for predicting drivers’ route choices along with the corresponding traffic flows and speeds in a transportation network
- Two main computational components
  - Traffic (simulation) model
  - Assignment (route choice) model
- Complementary tool to existing transportation network models
  - Static assignment (travel demand forecasting) models
  - Traffic micro-simulation models
- DTA is designed to address applications that fall in-between static-assignment and micro-simulation applications


network size
megalopolis
metropolis
city
wide area
multi-route corridor
corridor
isolated intersection
static assignment
equilibrium DTA
conventional microsimulation
planning
operations
design
traffic fidelity

DTA networks and properties

- Large models and congested traffic conditions, resulting in complex route choices
  - → Network subareas, Long corridors, Citywide models
- Traffic congestion is captured using a traffic simulation approach
  - → More sensitive and realistic than TDM, more detailed with respect to causes and effects of traffic congestion, explicit traffic control
  - → Fewer parameters than micro-sim models; parameters have physical interpretation
- Modeling average-day conditions requires equilibrium route choice which is stable and optimal
  - → Route choices are not determined exogenously (user input) as is typical in micro-simulation

Route Choice in Equilbrium DTA

- *Iterative assignment model:* the traffic simulation is repeated many times over (many iterations) in a single model run
  - First iteration: drivers choose paths based on free-flow travel times as congested travel times are not yet known
  - Each progressive iteration: drivers adjust their route choices based on the travel times of the previous simulation (“day to day learning”)
- *Equilibrium conditions*: key objective which should be achieved at the end of a model run
  - for each Origin-Destination pair, and each departure interval, experienced travel times (costs) over all used paths are approximately equal

Traffic Simulation in Dynameq

- Explicit modeling of vehicle interactions
  - → Simplified microscopic approach
- Captures key mechanisms of traffic breakdowns / congestion
  - → Strict flow capacities
  - → Spill-back of congestion (“blocking back”)
  - → Throughput (congested volumes) is volume-dependent
- Fewer parameters than conventional micro-simulation models while still capturing the key mechanisms of traffic breakdowns / congestion
- Event-based simulation and multi-threaded computations result in very fast run times

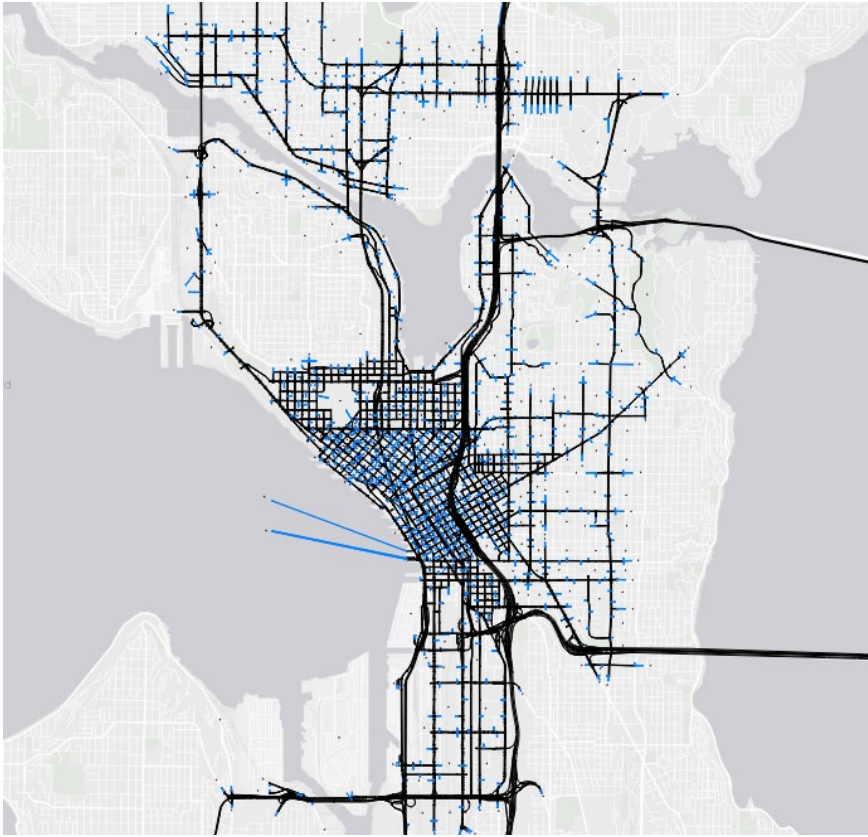
Sample DTA Applications with Dynameq

Seattle Alaskan Way Viaduct Replacement

- Tolled tunnel to replace urban freeway

Level 2 and 3 (investment grade) Toll Studies & EIS

- Toll forecasting
- Route diversion
- Construction mitigation
- Reversible lanes
- Traveller response to tolls and HOT lanes

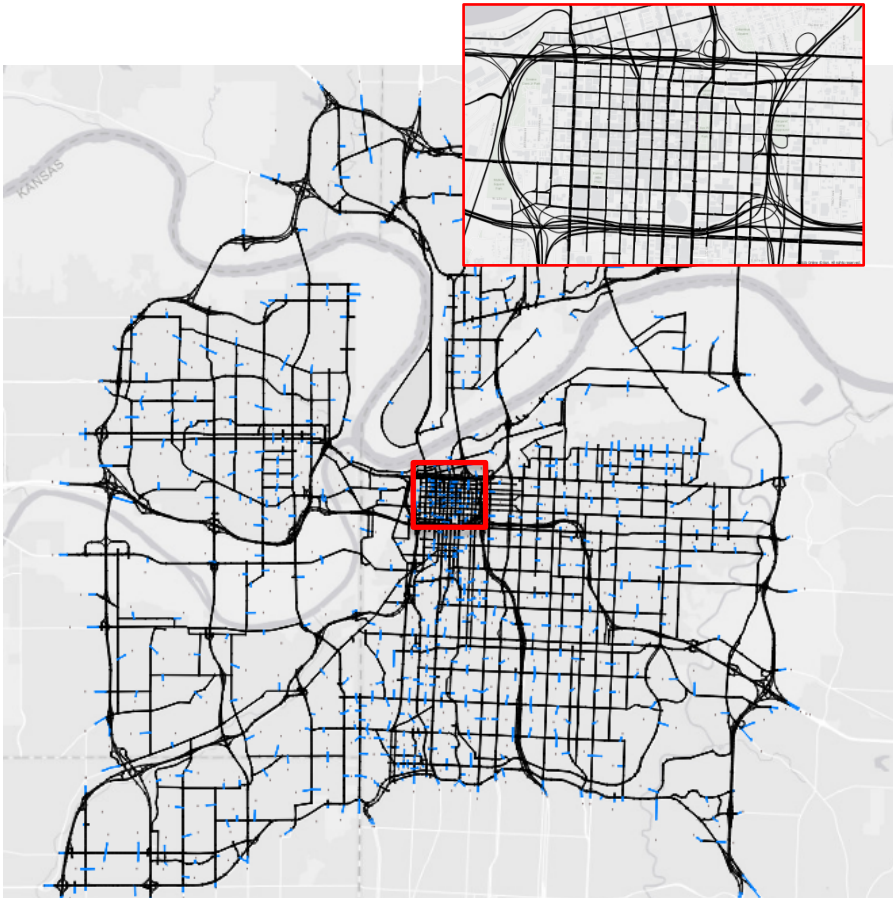


Kansas City, USA

- Dense CBD core with physical constraints
- Base year calibration completed 2017

Objectives

- Improvements to overall traffic flow and accessibility in CBD core
- Evaluating alternatives to the US-169 corridor
- Focus on I-70 corridor and connections to street grid in the downtown area

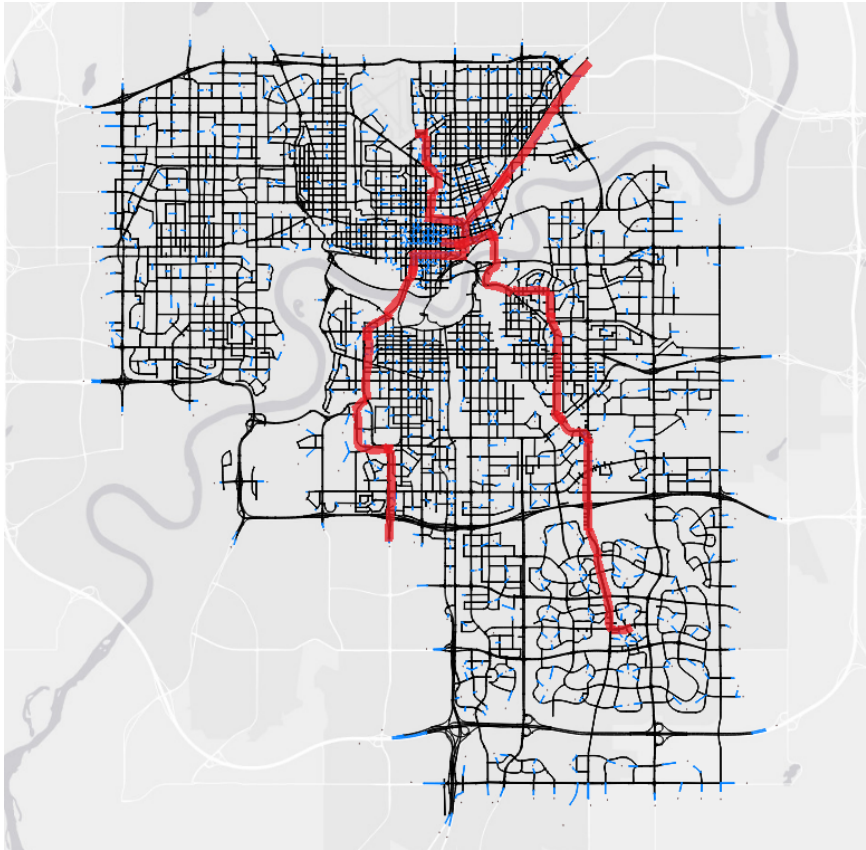


Edmonton LRT Model

- 13 km low-floor urban style LRT
- 12 new stations + 1 P&R / transit center
- Predominantly built at-grade
- $1.8 B in P3 delivery
- In construction, opens 2020

- **Fully simulated transit system preemption (TSP)**

- Valley Line West LRT (14km long, $1.8 billion) and Metro Line LRT North Extension (11 km, > $2 billion):
  - 2027 and 2047 Dynameq models were used to project traffic diversion impact due to LRT
  - Traffic routing used for post-analysis
  - Off-corridor impacts analyzed using Dynameq



I5 Freeway Phase 2

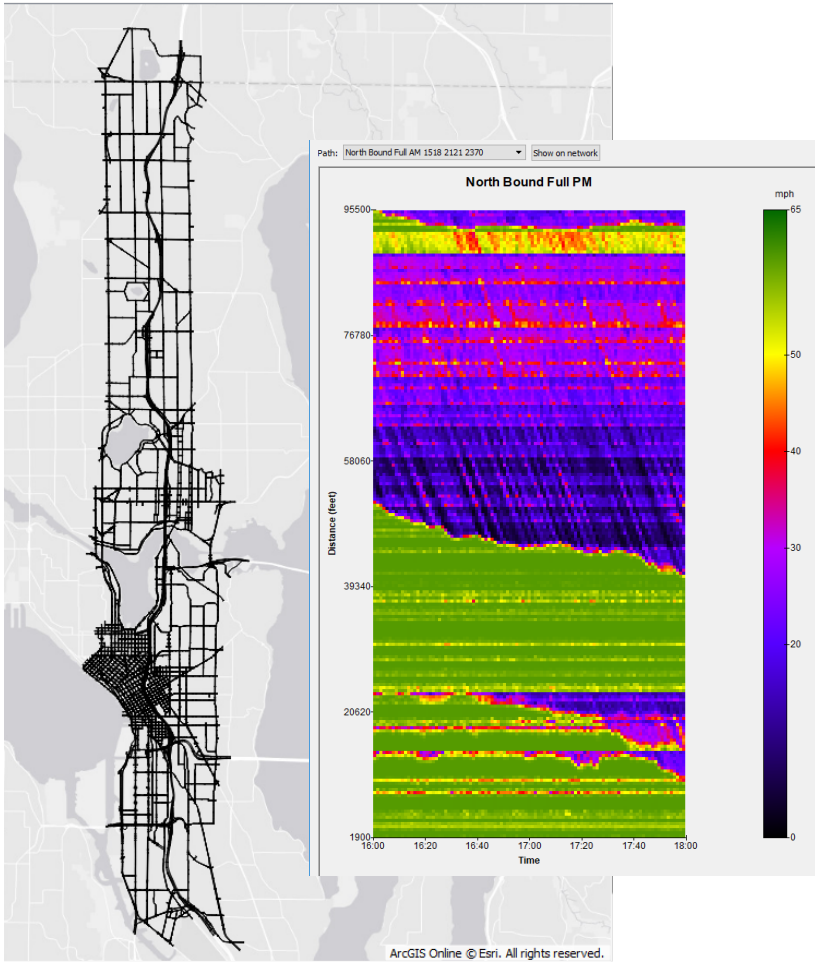
- Full corridor including main parallel facilities and city core from SR99 project
- Time-of-day reversible lanes
- Operational strategies (Tolls, Ramp Metering, Hard Shoulder Running, Reserved Lanes)

Calibration

- 4 sequential hours
- volumes and travel times on major facilities

Future year 2025: operational strategies

- New ramp meters with queue storage
- Transit only contra-flow lane



San Francisco

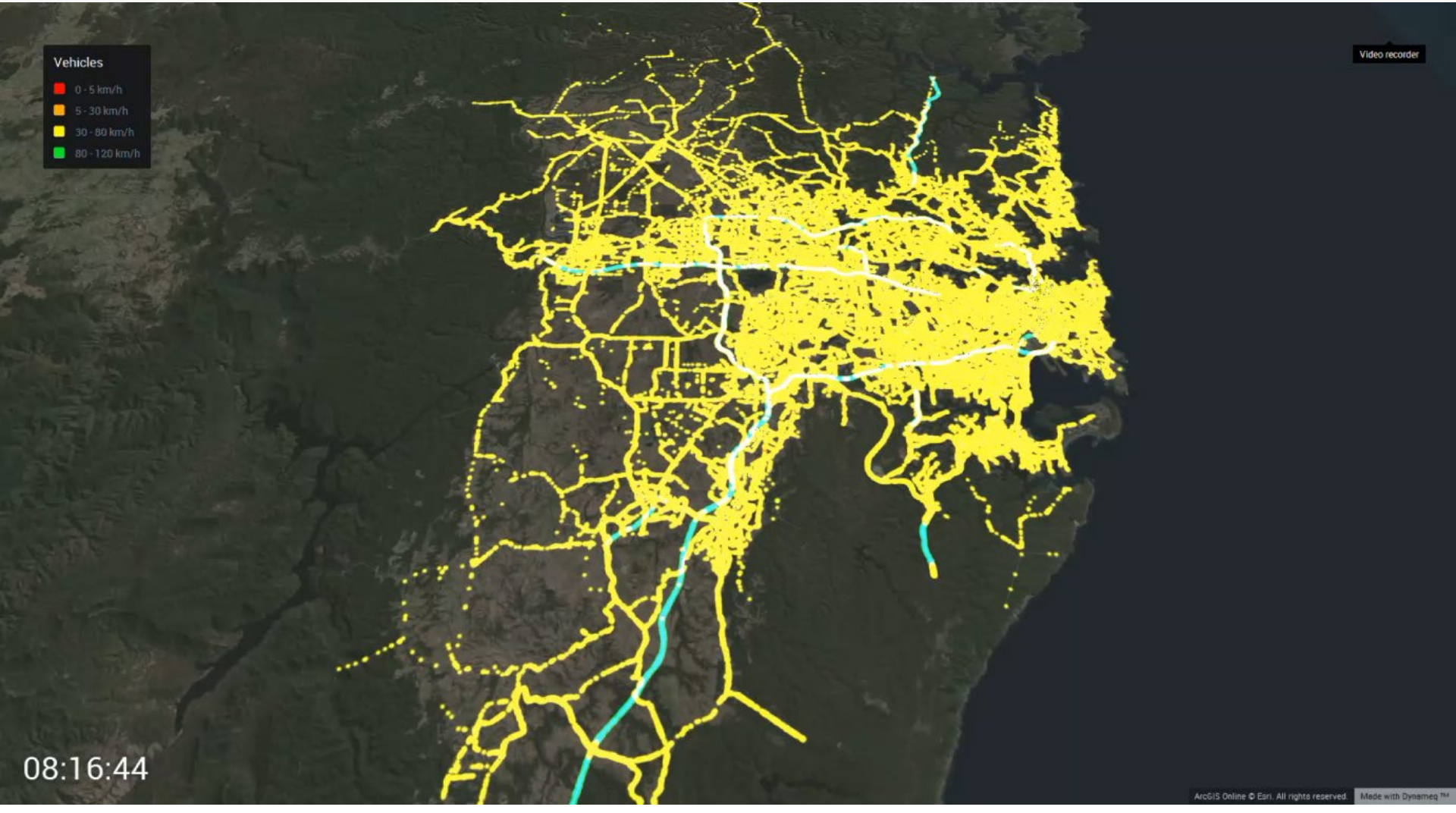
- Citywide model used to study a wide range of development plans

Applications

- Reconstruction of major roadways
- Bus rapid transit corridors
- Corridor Management
- Neighbourhood Transportation Plans
- Site Development

Model Specs

- 170 km^2
- 5 hr demand / 625,000 trips
- 2 classes + transit
- RAM = 14 GB


Vehicles
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30 - 80 km/h
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Made with Dynameq ™

Data, Calibration, and Limitations of DTA Models

Data, Calibration, Limitations of DTA Models

- Larger scale simulation models pose a number of significant data challenges:
  - Lack of high quality comprehensive data: network, control parameters and algorithms
  - Traffic analysis zones (TAZ) are often quite large
  - High quality / coverage for calibration data
- Calibration approach needs to be adjusted accordingly
  - Focus on key corridors and facilities
  - Calibration data is restricted to the highest quality and relevant year (self consistent)
  - Goodness-of-fit thresholds are lower than those for microsim corridor models
- Greater focus on risks of “over calibration”: this is a good trend!

Data, Calibration, Limitations of DTA Models

- Data quality and quantity
  - Demand data (O-D matrices) typically has the highest level of uncertainty of all the data going into the models
  - Calibration data is probably a close second
  - Network related data, though not perfect, has much less uncertainty than the above
- Modelling approach / assumptions
  - Traffic simulation: generally can capture the key traffic breakdown phenomena
    - not a source of significant limitations
  - Route choice: uses rules encoded in generalized cost expressions
    - not practical to be defining route choice manually for typical DTA models – also, doing so could be a risk of over calibration

Data, Calibration, Limitations of DTA Models

- Why is DTA particularly concerned with:
  - **data quality** (which is limited) and
  - **goodness-of-fit** expectations (need to keep reasonable) and
  - **over-calibration** (which is dangerous)
- It comes down to the questions that we are asking of DTA models – typically involve future/build scenarios with *major changes* to traffic volumes / conditions:
  - Major changes to network => major changes to route choice
  - Major changes to demand (e.g. long term horizons) -> major changes to route choice
- These applications depend heavily on the *transferability* of the calibrated parameters, which makes them sensitive to over-calibration: *data quality must not be over-estimated*

Data, Calibration, Limitations of DTA Models

- DTA applications in practise are thus focused on *larger scale interventions*:
  - Rehabilitation of major facilities
  - Significant changes in traffic control schemes, toll / pricing schemes
  - New green field developments
- DTA outputs primarily focused on:
  - Volumes and speeds on major facilities
  - Aggregate (area wide) impacts such as VMT, VHT
  - Aggregate / overall route choices and their impacts, e.g. tolls / pricing impacts
- Improved data sources, especially for networks and traffic data, are becoming more accessible and getting used more frequently: this is a good trend!

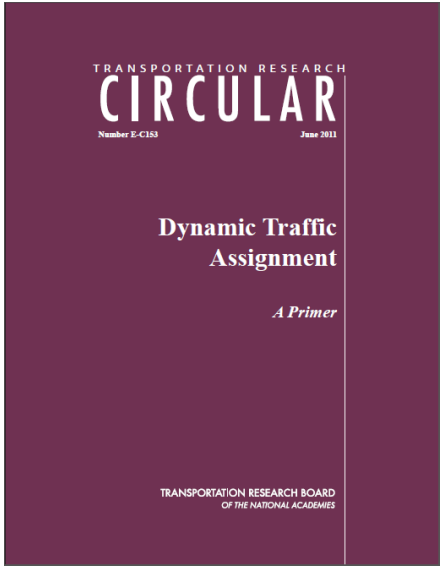
Further Reading

DTA Motivation and Overview

- "Interest has grown in applying traffic analysis tools capable of analyzing travel activities and dynamic network performance for a corridor or region over peak hours or even extended daily hours."

- "DTA models supplement existing travel forecasting models and microscopic traffic simulation models."

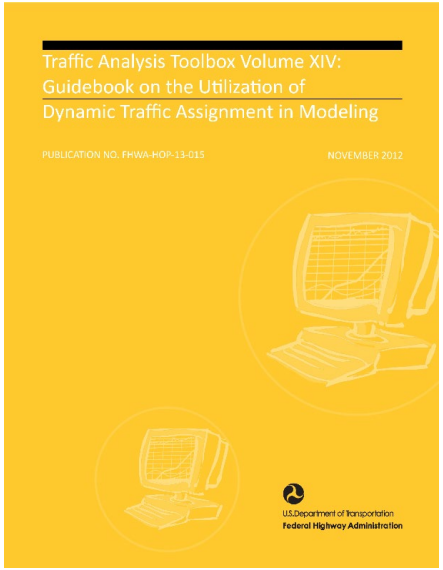
http://onlinepubs.trb.org/onlinepubs/circulars/ec153.pdf



DTA Guidelines Document (FHWA – USA)

- “The purpose of this guide is to provide practitioners with guidance on how to apply DTA within transportation models.”
- “This guide provides a set of proven approaches to model building, calibration, and alternatives analysis.”

http://ops.fhwa.dot.gov/trafficanalysistools/



Edmonton Case Study

Learn how the City of Edmonton is leveraging a Dynameq™ citywide traffic simulation and dynamic traffic assignment (DTA) model to consistently inform multiple operational planning studies in support of the city's Transportation Master Plan and its holistic view of transport as an interconnected, multi-modal system.

Video Gallery

Videos

Dynameq Vimeo Gallery

https://vimeo.com/showcase/6735154

password: inro2020rm

Thanks!

Michael Mahut, VP Simulation, INRO
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Simulation and Capacity Analysis User Group – Louisiana
Educational Meeting #6 - Sept 10, 2020

INRO

Open Discussion

Thank You for Attending!

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https://simcap.eng.lsu.edu/