



New Directions in Mathematical Approaches for Traffic Flow Management

Workshop IV: Decision Support for Traffic



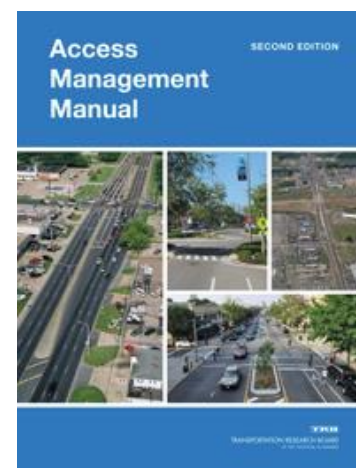
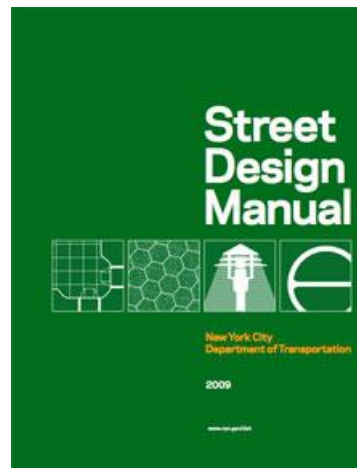
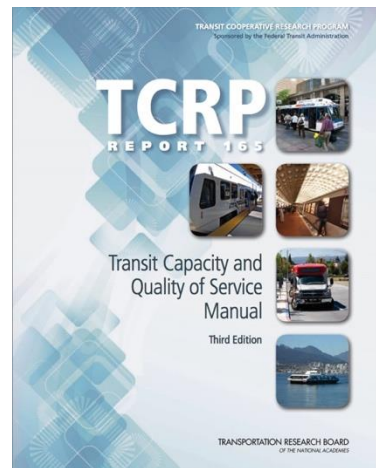
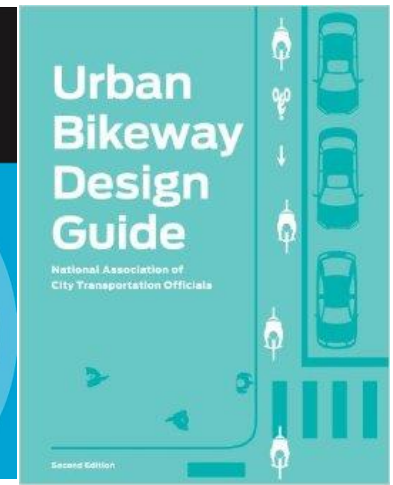
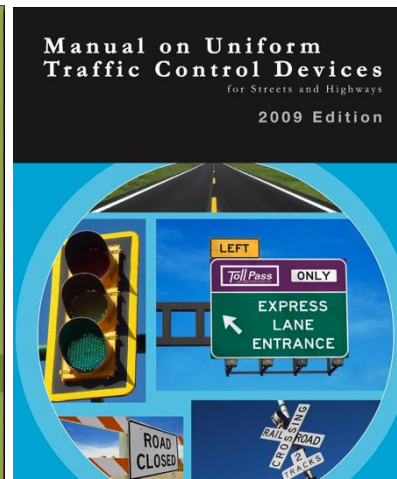
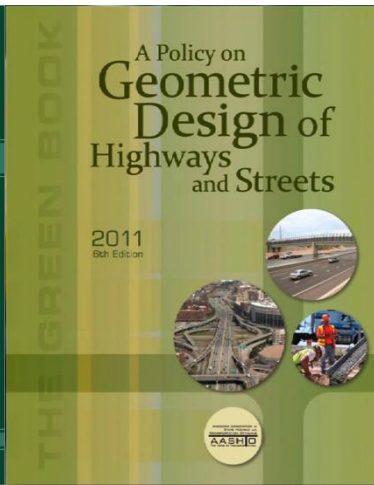
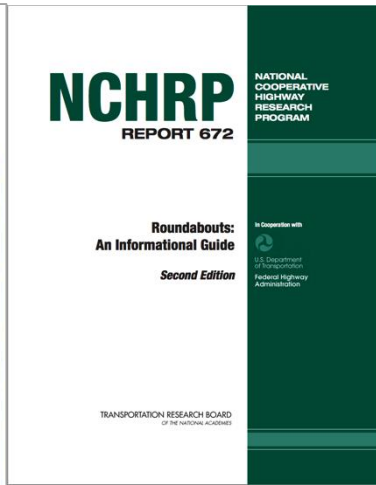
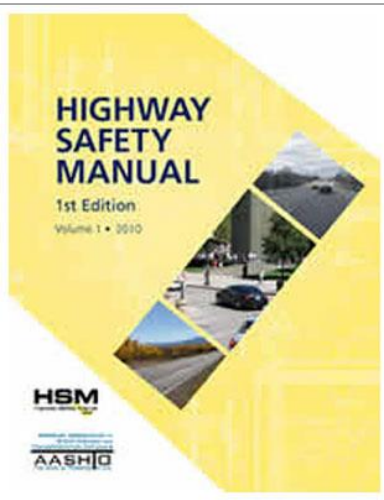
Multimodal Transportation System Simulation Manual (TSSM) Framework: From Theory to Practice

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California Polytechnic State University San Luis Obispo

November 17, 2015

Existing Transportation “Manuals” in the U.S.



Some History

1963: TRB Committee on Traffic Flow Theory and Characteristics

1964: HRB Special Report 79 Introduction to Traffic Flow Theory

1975: TRB Special Report 165 Traffic Flow Theory: A Monograph

2001: Traffic Flow Theory Monograph

2005: Joint Simulation Subcommittee (SimSub) Established

2008: Woods Hole - Greenshields Symposium

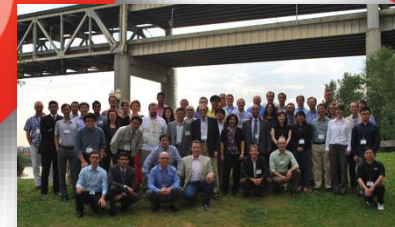
2010: Annecy - Does Traffic Data Support Traffic Models?

2012: Fort Lauderdale – Joint Summer Meeting with HCQS Committee

2014: Portland - TFTC 50th Anniversary Symposium

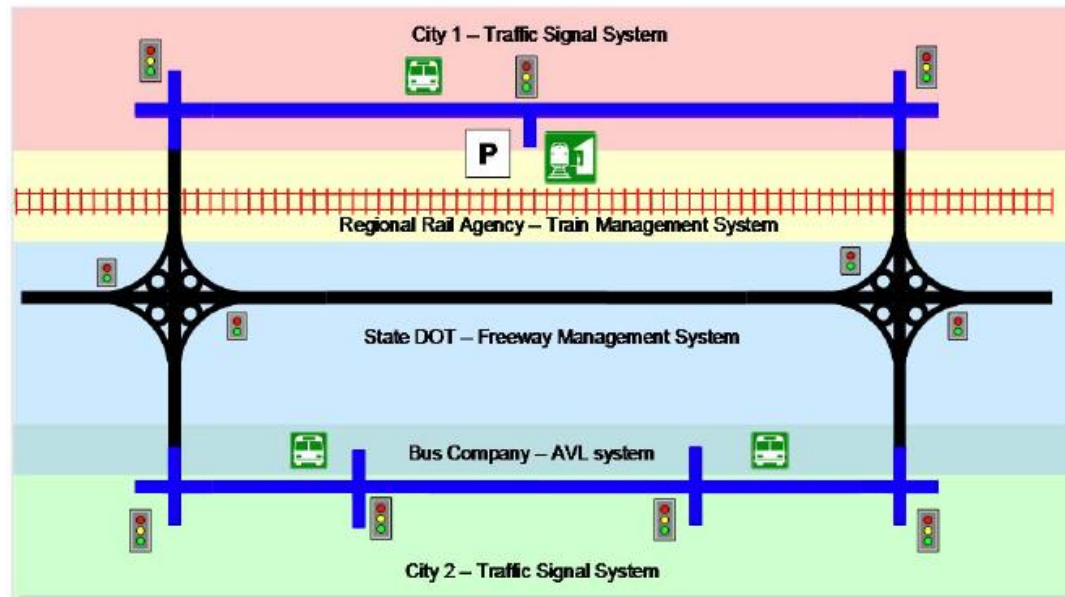
2015: TRB System Simulation Task Force Established

TSSM



Motivation

- Demand for simulation applications on the rise
- Transportation networks becoming more complex and multimodal (highway, rail, transit, bicycle, pedestrian)
- Need to improve the effectiveness of simulation applications
- Benefits to having a single, unified, collaborative resource



Project Objectives and Outcome

➤ Objective of this Project

- Create framework for evaluation of transportation systems; deliver to users the concepts, guidelines and procedures of simulation modeling

➤ Ultimate Goal of Manual

- Address at a minimum differing scales of modeling, integration of models, model inputs and data formats, data summary and analysis, data storage and model reuse, calibration/validation of simulation, alternative analysis, post processing of model data and interpretation of results

➤ Simulation Manual Will

- Maintain flexibility to accommodate future advances in modeling methods, input sources and data collection/processing methods.
- Ensure consistency, transparency and defensibility in development, selection, application, calibration and validation of simulation models/tools.

➤ Key Outcome

- Request funds from the NCHRP program and other funding sources for the development of the full manual.

Project Team

FHWA Project Management

- Justin Wagner (COR)
- John Halkias (Technical Contact)

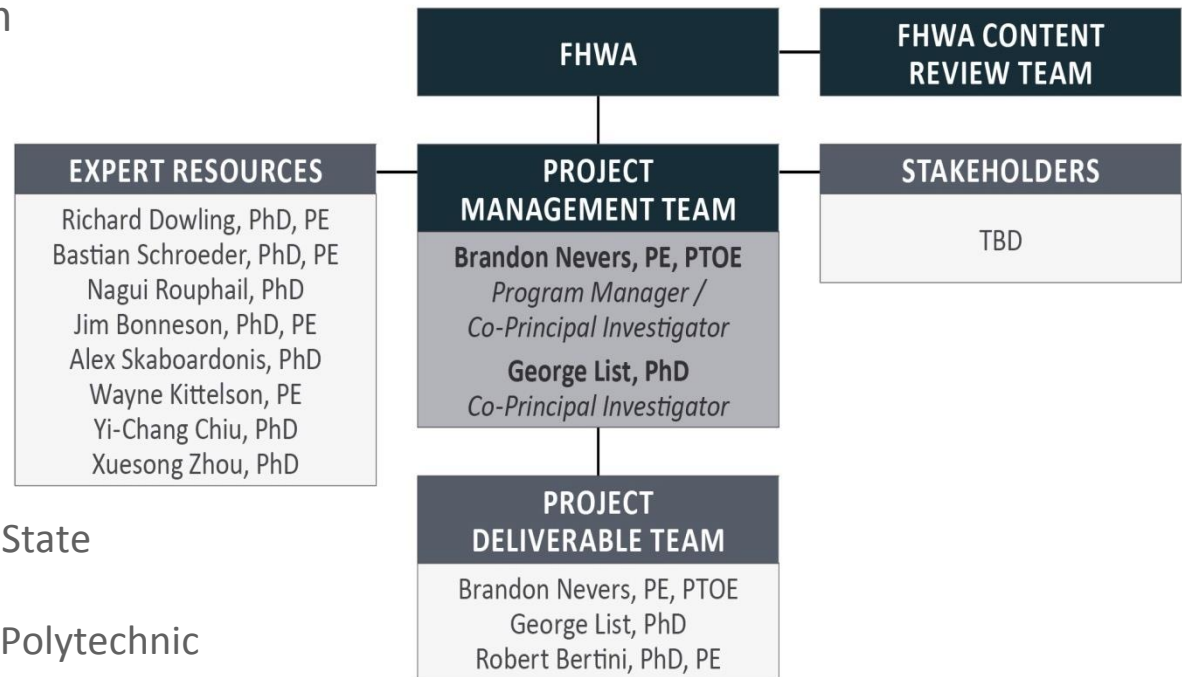
FHWA Content Review Team

- Joe Bared
- Philip Bobitz
- James Colyar
- Kris Milster
- Jim Sturrock
- Chung Tran

Kittelson & Associates

- Brandon Nevers (PM)
- George List, North Carolina State University
- Robert L. Bertini, California Polytechnic State University San Luis Obispo


Organizational Chart



Project Schedule

- Project kicked off September 16, 2014
- 12-month project
- Period of Performance ends September 2015

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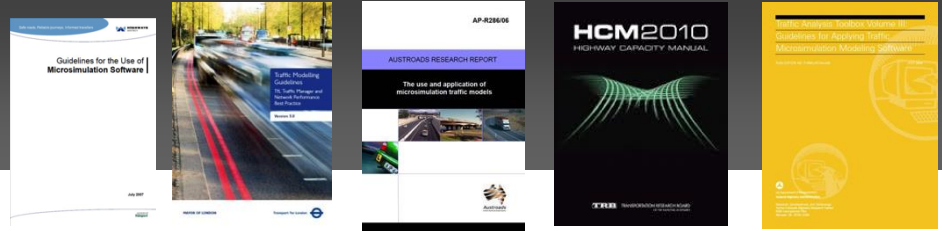
		<i>Month</i>	1	2	3	4	5	6	7	8	9	10	11	12
A	Project Management													
B	Synthesis of Existing Documents													
C	Stakeholder Workshop													
D	Annotated Outline													
E	Sample Chapter													
F	Research Problem Statements													

 = Kick-off Meeting

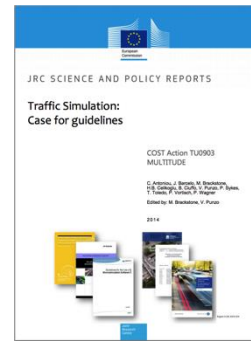
Synthesis of Existing Documents

- Complete in-depth synthesis of available literature and relevant documents related to simulation application and guidance
- Clearly and comprehensively synthesize best practice in simulation application across federal and state agencies, as well as internationally
- Document gaps in the available resources to ultimately strengthen the argument that a comprehensive simulation manual is needed

Existing Guidelines



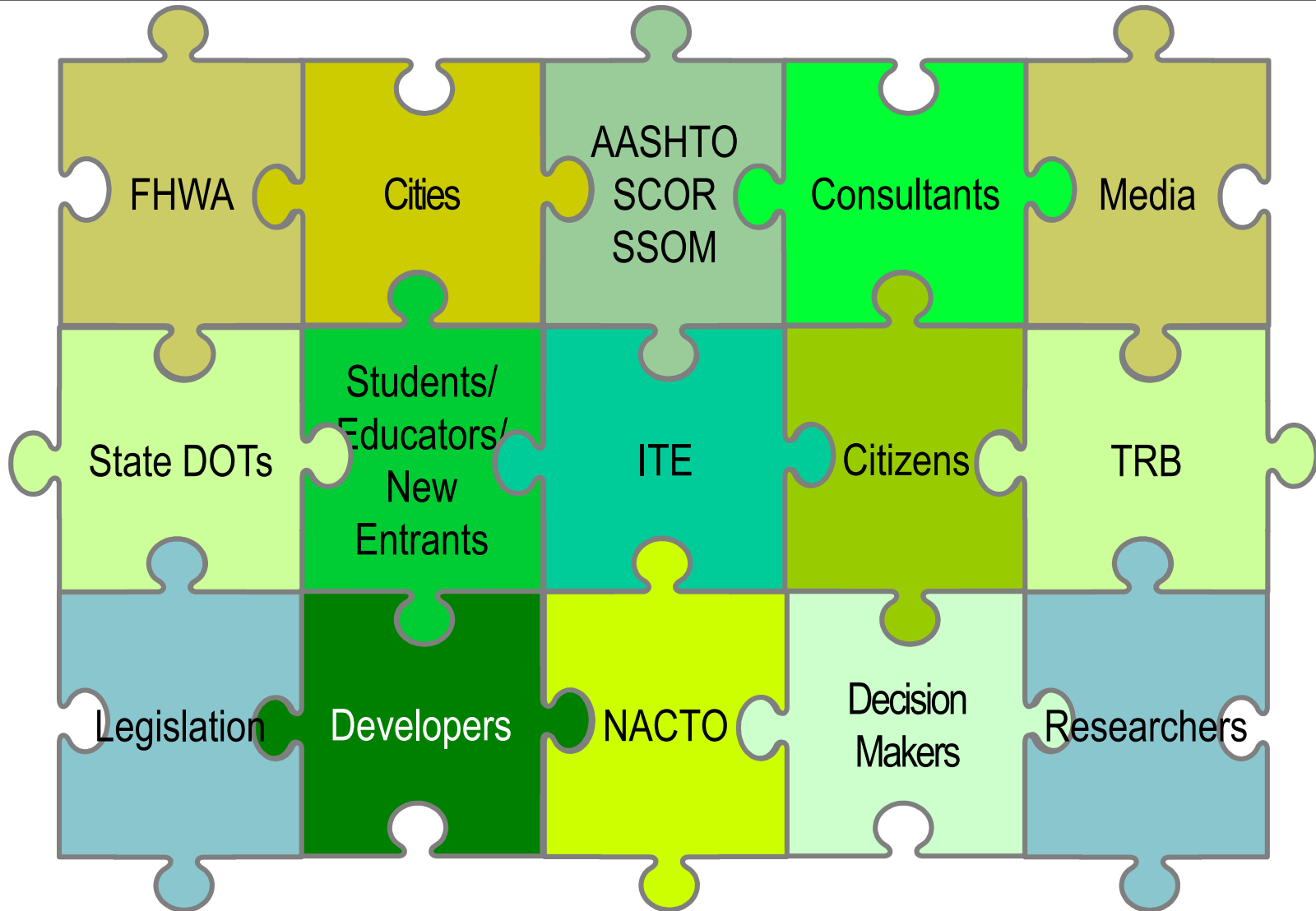
- U.S. Traffic Analysis Tools ops.fhwa.dot.gov/trafficanalysisistools
- U.S. NCHRP 3-85 Alternative Tools in Capacity Analysis
- Highway Capacity Manual (Vol 1-4)
- State DOTs: CA, VA, WA, OR, MN
- MULTITUDE Traffic Simulation: Case for Guidelines
- UK: Design Manual for Roads and Bridges (DMRB), Transportation Analysis Guidance (WebTag), Highways Agency Guidelines, TfL Traffic Modelling Guidelines
- Australia: Use and Application of Microsimulation Traffic Models, Guidelines for Selecting Techniques for Modeling Network Operatinos, Microsimulation Technical Notes, New South Wales Traffic Modeling Guidelines
- Germany: Notes on Microscopic Traffic Flow Simulation (FGSV)
- Canada: Best Practices for Technical Delivery of Long-Term Planning Studies
- New Zealand: Economic Evaluation Manual
- Japan: Standard Verification Process for Traffic Flow Simulation Models



Issues Within Existing Guidelines

- MULTITUDE Project Issues
 - Structuring simulation project/calibration activity
 - Model 'warm up' and 'cooling down' periods
 - Multiple run and sensitivity analysis requirements
 - Calibration and validation definitions and methodologies
- Other Issues
 - Safety Assessment
 - Environmental Concerns (e.g. emissions, energy consumption, noise)
 - Multimodal: Transit, Pedestrian, Bicycle
 - Connected and Automated Vehicles
 - Multi-scale Models, including Mesoscopic and Macroscopic
 - Evacuation/Emergency Situations
 - Agent Based Simulation

Stakeholders



Stakeholder Outreach

- Workshops/Listening Session/Webinars to help identify:
 - Content
 - Gaps
 - Additional sources
 - Identify the target audiences for the products
- Link with existing/project organizations focused on simulation best practices:
 - MULTITUDE (calibration/validation/primer/guidelines)
 - HEART European Association for Research in Transportation
 - NEARCTIS European Traffic Management
 - EWGT Euro Working Group on Transport
 - ISTS International Symposium of Transport Simulation
 - Japanese and Australian communities
- Focus groups/follow up survey
- Open lines of communication
- Building on past efforts/leveraging ongoing or planned events

We're building a campaign, not a workshop!

Simulation Manual Annotated Outline

- Build on information obtained from the synthesis of existing relevant documents, stakeholder workshop and other stakeholder input
- Be detailed enough to clearly describe each section of the manual
- Incorporate the most recent results of international and U.S. research and practice
- Ultimate format will be “online” with print on demand capability (Wikibook concept as inspiration)

Ingredients of Simulation Manual Sample Chapter

- Strong theoretical basis for the particular topic
- Valid connection to real transportation problems
- Presentation of state of the art and existing available tools
- Solid list of references
- Step by step procedures aimed at practitioners
- Clear description of ways that practitioners should incorporate real data
- Clear discussion of calibration and validation needs/requirements
- Robust discussion of research needs and limitations of existing tools/methods

Ingredients of Simulation Manual Sample Chapter

- The first volume is divided into following four chapters:
 - Basic Concepts
 - About Computer Simulation (1)
 - Basic Simulation Ideas (5)
 - Common Algorithms and Algorithm Types (10)
 - Stochasticity (6)
 - Techniques for Creating the Model Logic
 - Real-Time Concurrent Simulation (16)
 - When to Apply Simulation (3)
 - Computer Simulation Applications (2)
 - Types of Computer Simulation Modes (4)
 - Model Building
 - Model Building Process (7)
 - Scenarios (13)
 - Verification and Validation (8)
 - Common Pitfalls of Simulation (9)
 - Special Features
 - Simulation of Pedestrian Movements (11)
 - Simulation of Transit Activities (12)
 - Safety Assessments (14)
 - Emission Assessments (15)

Possible Research Problem Statements

Application Oriented – Fill Gaps – Input Welcome

1. Performance Measures
2. Models of Traveler Behavior
3. Models of Connected and Autonomous Vehicles
4. Multi-resolution simulation
5. Active Transportation Demand Management (ATDM)
6. Integrated Corridor Management
7. Real Time Predictive Modeling
8. Calibration and Validation
9. Air Quality
10. Safety
11. TSSM Planning and Production

TSSM: What It Is, and What It Isn't

> What it is:

- Multi-author document with consensus-based materials (HCM, HSM, TCQSM, etc.)
- Description of simulation options (e.g., micro-, macro-, and meso) and use
- Discussion about inputs, outputs, output expectations, number of simulations, control of random number sequences, etc.,
- Example simulations using open-source simple simulation models to illustrate concepts
- Guide for users, developers, modelers, reviewers
- Document that can be used as a reference for classes, tutorials, workshops, etc.

> What it isn't:

- Single author or single agency document
- Proscriptive guide for doing simulation analyses (Volumes 2 and 3 of HCM)
- Guide to commercial software selection
- Source of comparisons of commercial simulation software packages

A Few Key Challenges

1. Ensuring the TSSM is more than just a compilation of research and best practices; it must provide definitive guidance where needed
2. Striking a balance between a heavily-prescribed approach and an unbounded one
3. Ensuring the TSSM is evolving and flexible enough to accommodate rapidly changing advances in technologies
4. Developing a Framework that is independent of software
5. Producing and maintaining a manual where the knowledge and expertise spans multiple committees/subcommittees/disciplines

Possible Organization

- Volume I: Concepts, Definitions
 - Basic ideas, time and event-based paradigms, scale choice, calibration, validation, and verification, IT issues, command and control
- Volume II: Freeway Systems
 - Basic elements, typical simulation treatments, modeling of specific situations, treatment of disruptions
- Volume III: Surface Arterial Systems
 - Basic elements, typical simulation treatments, modeling of specific situations, treatment of disruptions
- Volume IV: Combined Freeway/Arterial Systems
 - Modeling issues, coordination issues, IT issues, system management issues, management of OD patterns
- Volume V: Supplementary Materials
 - Case study examples, CV&V documents

Possible Organization

- Volume I: Concepts, Definitions
 - Basic ideas, time and space, choice, calibration, validation, and verification control
- Volume II: Freeway
 - Basic elements, treatments, models, specific situations, treatment conditions
- Volume III: Supplemental
 - Basic elements, simulations, models, specific situations, treatment conditions
- Volume IV: Corridor Freeway/Arterial
 - Modeling issues, management issues, IT issues, management issues
- Volume V: Supplemental
 - Case study examples, C

Potential Structure for TSSM

- **Volume I: Concepts** – basic ideas related to simulation and its use in modelling transportation systems.
- **Volume II: Model Development** – developing the model for use in specific contexts including freeway, arterial, transit, and pedestrian subnetworks, the demand inputs, the technical details of the communication system, and the scenarios and their frequency of occurrence.
- **Volume III: Preparation For Use** – checking to see that the model is ready for use, including calibration, verification, validation, and other performance assurance testing strategies.
- **Volume IV: Results Development And Analysis** - making model runs, tracking the results, analyzing the outputs
- **Volume V: Supplementary Material** – example case studies, additional guidance documents, and references to other material that is helpful in showing users how to develop, test, and employ simulation models.

INTERNATIONAL PERSPECTIVES

- Link with existing/project organizations focused on simulation best practices:
 - Former MULTITUDE constituencies (calibration/validation/primer/guidelines)
 - HEART European Association for Research in Transportation
 - NEARCTIS European Traffic Management
 - EWGT Euro Working Group on Transport
 - ISTS International Symposium of Transport Simulation
 - Japanese and Australian communities
- Focus groups/possible January meeting/follow up survey
- Open lines of communication
- Building on past efforts/leveraging ongoing or planned events

TRB Task Force Background

- Simulation community has identified a need to launch a deliberate effort to plan, develop and produce a TSSM and identify funding opportunities
- TRB Traffic Flow Theory Committee + Simulation Joint Subcommittee (SimSub) provide oversight.
- A new TRB Special Task Force will oversee development of the TSSM, housed under the Operations Section, collaborate with other committees/subcommittees
- The task force would “own” the TSSM development process and oversee its production
- To be comprised of members of state DOTs, other agencies, practitioners, consultants, model developers, academics/researchers, and international representation
- Need to inspire research problem statement → action and ongoing activities

What is a TRB Task Force

- Address specific well-defined problem or task that encompasses the scope of more than one unit in a Group.
- Three year time window. May be renewed.
- Evaluation criteria:
 - Clarity of scope and task.
 - Evidence of need, demand and potential accomplishment.
 - Evidence of uniqueness.
 - Clear indication of planned activities (sessions, workshops, webinars, circulars, research problem statements)
- Chair duties:
 - Plan, lead and direct work of task force
 - Conduct meetings,
 - Submit interim or final report to Group Executive Board

TRB System Simulation Task Force

- Housed under Operations Section within the Operations and Preservation Group.
- Three year term (until 4/14/18) after which evaluation will occur for extension or sunset
- **Scope:** concerned with the analysis of transportation systems through the application of mathematical modeling and computer software to help plan, design, and operate the transportation systems in increasingly constrained, congested and complex multimodal environments.
- **Membership:** diverse and inclusive including representatives of TRB committees, FHWA, State DOTs, other transportation agencies/practitioners, consultants, model developers and academics/researchers. Include international representatives.
- **Products:** Plan, develop and produce a Transportation System Simulation Manual.

TRB Task Force

- *Approved by TRB June 10, 2015*
- 27 Members* through 4/14/18
- Chair: Calvin Leggett, North Carolina Department of Transportation
- Task Force “Friends” are welcome!
- Website TBA
- A collaborative effort will help mainstream and unify simulation practices
- Funding is needed to develop the TSSM; requires support of program sponsors
- Building a “village”



*some members play multiple roles

TRB Task Force

> Northwest Well Represented

- Randy Johnson, DKS
- LisaRene Schilperoort, WSDOT
- Jongsun Won, PTV



*some members play multiple roles

TRB Operations Section

Technical Advisory Committee (TAC)

Operations and Preservation Group AH000

Operations Section AHB00

Maintenance and Preservation Section AHD00

Surface Transportation Weather AH010

Regional Transportation Systems Management and Operations AHB10

Intelligent Transportation Systems AHB15

Freeway Operations AHB20

Traffic Signal Systems AHB25

Vehicle-Highway Automation AHB30

Managed Lanes AHB35

Highway Capacity and Quality of Service AHB40

Traffic Flow Theory and Characteristics AHB45

Traffic Control Devices AHB50

Work Zone Traffic Control AHB55

Highway/Rail Grade Crossings AHB60

Operational Effects of Geometrics AHB65

Access Management AHB70

12 Committees

Young Member Council

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Access Management AHB70

Young Member Council

Joint Simulation Subcommittee AHB45(1)

Networks ADB30

Air Quality ADC20

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Access Management AHB70

Young Member Council

Task Force on System Simulation AHB80T

Joint Simulation Subcommittee AHB45(1)

Networks ADB30

Air Quality ADC20

TRB Task Force “Nuts and Bolts”

- TRB Main Requirement: official meeting minutes (appoint a secretary)
 - Approved by chair and distributed to all members, section and group chairs, and TRB staff.
 - Post on website.
- Structure
 - Executive committee?
 - Other posts: deputy chairs, subcommittee structure, etc.
- Meetings
 - Traditional January meeting
 - Midyear meeting – sync with other committees/events
 - Intermediate phone/web meetings
- Coordinate with AASHTO: appoint liaison
- Coordinate with other TRB committees: appoint a liaison for each
- Website would be a useful repository (<http://sites.kittelson.com/TSSM> for now)
- Friends are Welcome!

NCHRP Project Selection Process

> NCHRP Projects

- October 15: State DOTs, AASHTO Committees and FHWA submit problem statements
- November: Panel reviews safety & operations problems
- February: State DOTs ballot on problems
- March: AASHTO Standing Committee on Research selects projects

> Status

- NCDOT Submitted TSSM First Edition Problem Statement on October 9
- Endorsed by: Florida, California, Ohio, Oregon, Washington, Maryland, Virginia
- Other Agency Involvement: DVRPC, NYCDOT, Atlanta Regional Commission, CMAP
- Need support through State DOTs and AASHTO Committees!

NCHRP Problem Statement

- \$600k/24 months
- Vision for \$2.5 million/72 months
- Process continues into early 2016

NCHRP Problem Statement Submission - FY 2017

2. Problem Statement

PROBLEM TITLE

Development Of A Transportation System Simulation Manual (tssm): First Edition

STATEMENT OF THE RESEARCH PROBLEM

Transportation System Simulation is the mathematical modeling of transportation systems through the application of computer software to better help plan, design and operate transportation systems. Simulation modeling software is widely used by state, regional and local transportation agencies and their consultants and its use is expected to rise given the growing emphasis on performance management, travel time reliability, multimodal solutions, performance-based design and connected/automated vehicles. Despite the importance of simulation, there is no definitive national guidance document on its use and application. Transportation agencies struggle to provide guidance and oftentimes lack resources to oversee and review its application. State DOTs and other agencies are asking for a national, definitive Transportation System Simulation Manual (TSSM).

Based on this need, and in partnership with key public and private stakeholders, TRB formed a task force on simulation (AHB80T) in July 2015 to oversee the development of a TSSM. This task force falls under the TRB Operations Section and coordinates with the Traffic Flow Theory and Characteristics Committee, the Joint Simulation Subcommittee (SimSub) and others. More than 25 members of the newly formed task force participated in a workshop in Washington, D.C. in September 2015 to develop the vision and future steps necessary to create the TSSM. During the workshop, the task force unanimously agreed to a vision and framework outline for the TSSM. Key elements of the vision are as follows:

- The TSSM should serve both technical and non-technical audiences and include educational components
- It should document a process for simulating multimodal transportation systems that include transit, pedestrians, bicyclists, freight, and passenger cars
- It should address multi resolution simulations (macro, meso, and micro)
- It should provide a standard for acceptance of simulation models
- It should provide a reference for "hands on" review of simulation results (e.g., agency oversight of consultant contracts involving simulation)

This research effort will develop the first edition of the TSSM based on today's state of the practice. There is strong support for its development not only among the TRB Simulation Task Force members but also across the broad simulation stakeholder community.

What Can You Do?

- We Need Your Involvement
- Check out TSSM Site <http://sites.kittelson.com/TSSM>
- Become a Friend of the Task Force @ www.mytrb.org (AHB80T)
- Talk to Task Force Members
- Talk to your State DOT SCOR representative
- Attend Task Force Meeting at TRB Annual Meeting (Monday 1:30-5:30)
- Attend Simulation Workshop (Sunday 1:30-4:30) at TRB Annual Meeting
- Poster Session 536 Tuesday 8:30-10:15 Hall E





Thank You for Your Attention

rbertini@calpoly.edu

<http://sites.kittelson.com/TSSM>

Become a “Friend” of the Task Force AHB80T
<https://www.mytrb.org/>