Traffic Analysis & Modeling for Weather Responsive Traffic Management (WRTM)

C. Y. David Yang, Ph.D.
Office of Operations R&D
Turner-Fairbank Highway Research Center
Federal Highway Administration

2011 Road Weather Management Stakeholder Meeting

Thursday, September 8, 2011
Albuquerque, NM

U.S. Department of Transportation
Federal Highway Administration

Presentation Outline

- Purpose of traffic analysis tools
- FHWA's traffic analysis & modeling projects related to WRTM
  - Microscopic Analysis of Adverse Weather on Driver Behavior
  - Traffic Estimation and Prediction Systems (TrEPS) Models

ROLE OF TRAFFIC ANALYSIS & MODELING TOOLS

3

- Operate & manage existing roadway capacity
- Improve decision-making process
- Project potential traffic of the future
- Evaluate & prioritize planning/operational alternatives
- Improve design and evaluation time & costs
- Present/market strategies to the public and stakeholders

4

Types of Simulation Models

- *Macroscopic Simulation Models* – based on deterministic relationships of the flow, speed, and density of the traffic stream; simulation takes place on a section-by-section basis
- *Mesoscopic Simulation Model*s – unit of traffic flow is the individual vehicle, assign vehicle types and driver behavior, as well as their relationships with roadway characteristics; vehicle movements are governed by the average speed on the travel link
- *Microscopic Simulation Models* – simulate movement of individual vehicles based on car-following and lane-changing theories; vehicles enter a network using statistical distribution of arrivals and are tracked through the network

5

FHWA'S WRTM PROJECT – *MICROSCOPIC ANALYSIS OF ADVERSE WEATHER ON DRIVER BEHAVIOR*

6

- *Study Team*: Cambridge Systematics and Virginia Tech
- This study analyzed the impacts of adverse weather (e.g., rain & snow) on microscopic traffic behavior – individual driver responses to weather conditions that included changing lanes, making left turns across traffic at an intersection, and adjusting the distance behind a lead vehicle

7

Project Objectives

- Study to better understand driver behavior during inclement weather and develop models to incorporate in existing micro-simulation tools in the following:
  - Car-following – characterize the behavior of a following vehicle (n) that follows a lead vehicle (n-1)
  - Gap acceptance – vehicles making left turns through an opposing through movement at a signalized intersection
  - Lane changing – 'necessary lane change' is made to follow the desired route & 'free lane change' is made to increase the vehicle's speed

8

Car-Following Models from Micro-Simulation Software

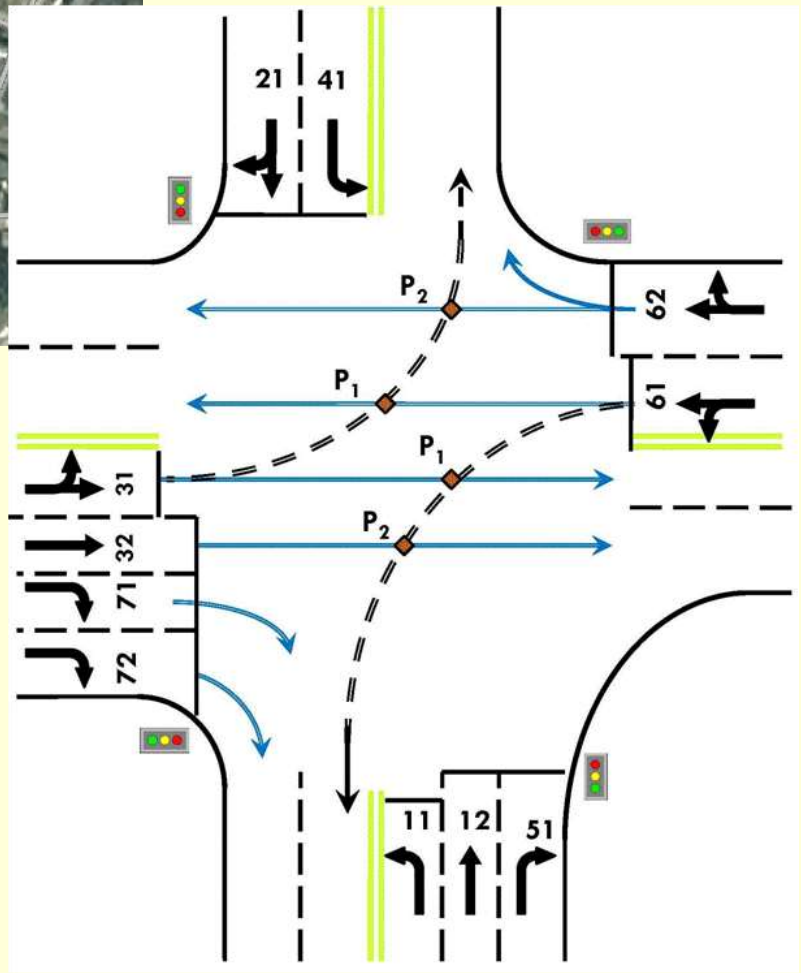
- Pitt model (CORSIM)
- Wiedemann74 & 99 models (VISSIM)
- Gipps' model (AIMSUN)
- Fritzsche's model (Paramics)
- Van Aerde model (INTEGRATION)

9

Gap Acceptance Case Study

- Signalized intersection of Depot and Franklin St., Christiansburg, Virginia
- Three phasing system; consists of 4 approaches intersect at approximately 90 degree
- The gap acceptance dataset used in the study included 11,114 observations (1,176 accepted gaps & 9,938 rejected gaps) for a permissive left turn maneuver at a signalized intersection gathered over a 6-month period


N Franklin St
Water St
Depot St N
Stuart St
Chapel St
Betty Dr
Pepper St N
Quality Rd
BR
460


21
41
P2
62
P1
61
P1
31
P2
32
71
72
11
12
51


F: 10533399


F: 02968616


F: 13014363


ROAD
CLOSED

Study Findings

- Logistic regression models reveal that drivers are more conservative during poor weather conditions – increase in the accepted gap size
- Gap acceptance increases when the road is covered with snow compared to wet road surface
- However, drivers became more aggressive as they wait longer for a gap

FHWA's WRTM Project –
TRAFFIC ESTIMATION & PREDICTION SYSTEMS MODELS

- *Study Team*: SAIC, Northwestern University, and University of Virginia
- In previous phase of this work:
  - A methodology for incorporating weather impacts in Traffic Estimation & Prediction Systems (TrEPS) models is developed
  - Addressed both supply & demand aspects of the traffic response to adverse weather, including user responses to various weather-specific interventions
  - Methodology was incorporated and tested in connection with the DYNASMART–P simulation-based DTA system, thereby providing a tool for modeling the effect of adverse weather on traffic

Project Objectives

- Current phase of this research:
  - Further calibrate and validate the methodological development made in the previous project to advance the state of practice of WRTM
  - Implement & evaluate WRTM strategies using TrEPS models in four locations
    - ✓ Weather-sensitive on-line TrEPS will be a catalyst for the advancement of effective WRTM strategies
    - ✓ Allows TMC to test and evaluate various site-specific traffic control/advisory plans
    - ✓ Includes DYNASMART-P (off-line) fully calibrated to local traffic and weather conditions and seamlessly extending its functionalities to DYNASMART-X (on-line) for the real-time operations

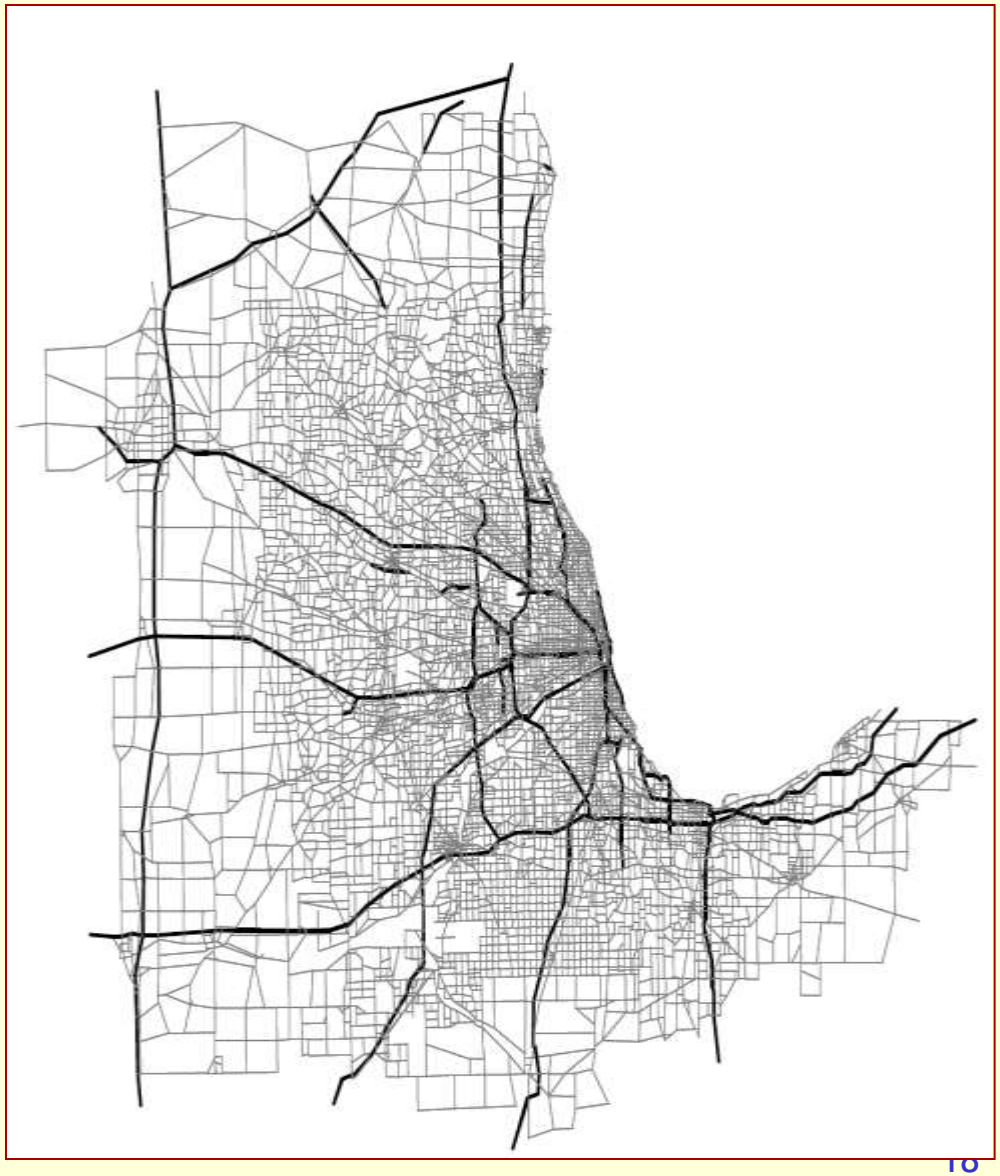
Potential WRTM Strategies

- Display weather information or warning on VMS (Advisory VMS)
- Display road closure information on VMS such as snowplowing operations, flooded area, … (Mandatory VMS)
- Adjust speed limits in response to prevailing weather conditions (Speed Management)
- Modify signal timing plans to improve traffic conditions under inclement weather (Signal Control)
- Modify ramp metering timing plans in response to prevailing weather conditions (Ramp Metering)
- Use demand management scheme to reduce the overall volume under adverse weather conditions such as restriction on single occupancy vehicle (Demand Management)

Network for TrEPS – Chicago

Network Description

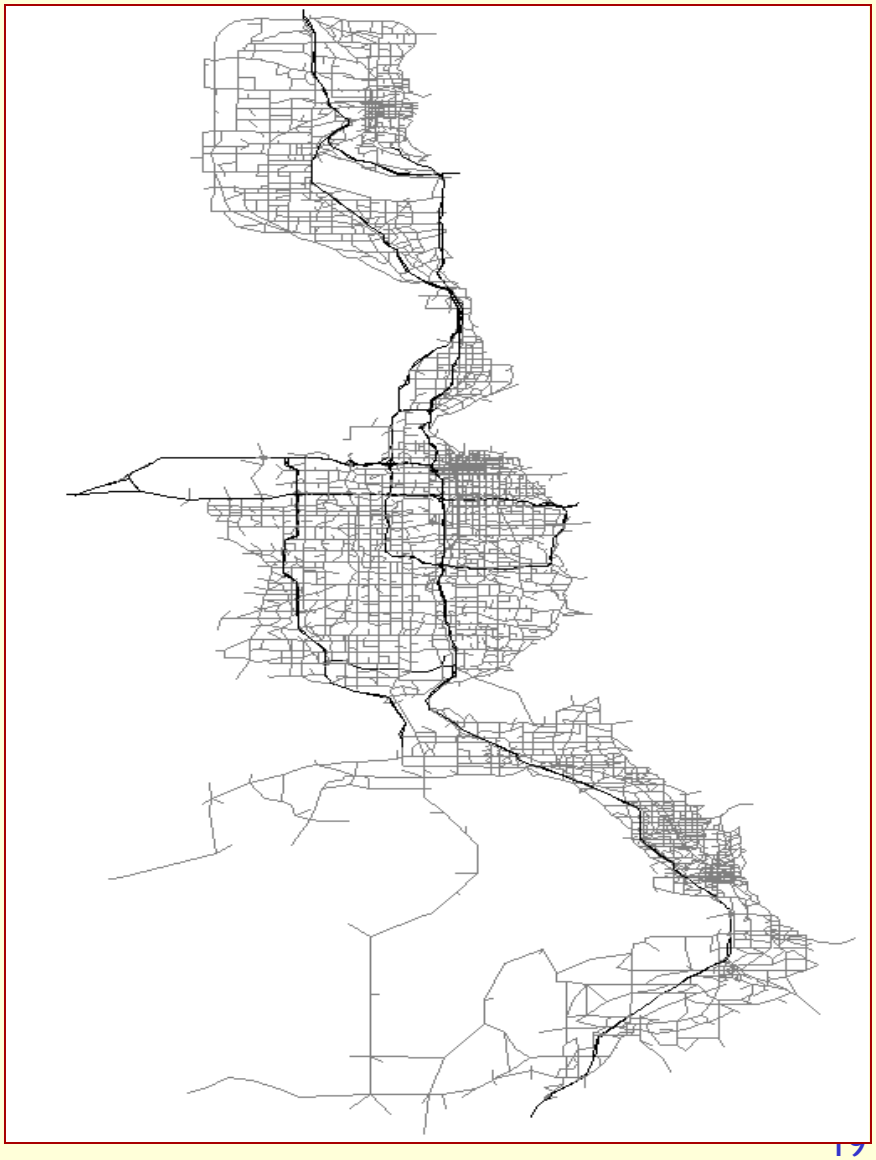
- 40443 links
  - 144 links are toll roads
  - 1400 freeways
  - 201 highways
  - 2120 ramps
  - 36722 arterials
- 13,093 nodes
  - 2,093 signalized intersections
- 1961 zones
  - 1,944 internal
  - 17 external
- Demand period
  - 5 - 10 AM
  - 355 links with observations used in calibration



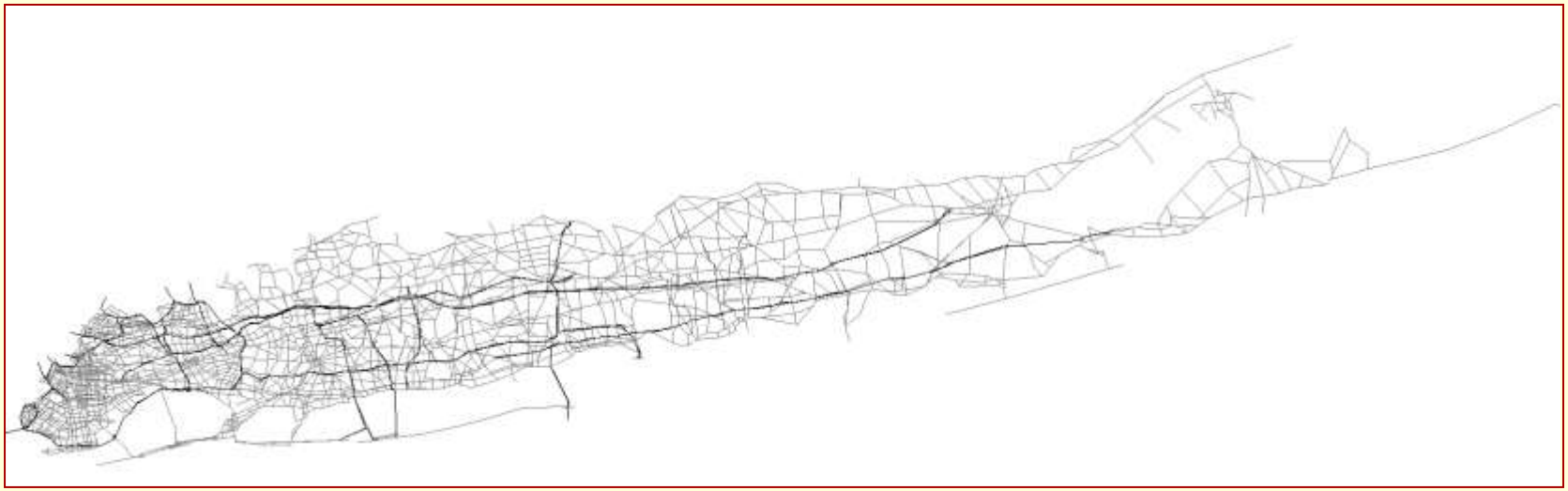
Network for TrEPS – Salt Lake City

Network Description

- 14,046 links
  - 1,893 freeways
  - 872 ramps
  - 11,281 arterials
- 8,707 nodes
- 1,500 zones
- Demand period
  - 6 – 9 AM
  - 12 links with observations are used in calibration



Network for TrEPS – Long Island



Network Description

- 21,791 links
  - 1,588 freeways
  - 14 links with tolls
  - 31 highways
  - 170 HOV facilities
  - 2,059 ramps
  - 17,943 arterials
- 9,403 nodes
  - 4,708 signalized intersections
- 1,431 zones
  - 1,421 internal
  - 10 external
- Demand period
  - 6 – 10 AM
  - 106 links with observations used in calibration

Contact Information

David Yang
FHWA Office of Operations R&D
(202) 493-3284
david.yang@dot.gov

Roemer Alfelor
FHWA Office of Operations
(202) 366-9242
roemer.alfelor@dot.gov

Discussion Questions

1. What WRTM strategies are being deployed in your state?
2. Do you use any analytical tool(s) to develop and select WRTM strategies?
3. Have you utilize any WRTM resources generated by FHWA and its partners?