

# OVERVIEW OF TRAVEL DEMAND MODELS



*One Region, Focusing on Our Future*

**ADVISORY COMMITTEES ON REGIONAL LAND USE AND  
TRANSPORTATION SYSTEM PLANNING**

**AUGUST 19, 2015**

# Outline

- ❑ Peer Review
- ❑ Model Structure
- ❑ Validation Statistics

# Peer Review

## ❑ Peer Review Panel:

- Keith L. Killough, AICP, Director of Transportation Analysis, Arizona Department of Transportation
- Guy Rousseau, Travel Surveys & Transportation Model Development Manager, Atlanta Regional Commission
- Kermit Wies, Deputy Director for Research and Analysis, Chicago Metropolitan Agency for Planning

## ❑ Met December 18, 2014 at the Chicago Metropolitan Agency for Planning in Chicago, Illinois.

## ❑ Jennifer Murray and Brent DesRoches from WisDOT were also in attendance.

# Peer Review (continued)

- Purpose of peer review was to identify “potential” changes to current model and model structure to ensure next generation travel demand model would consistent with current modeling techniques and practice.

# Overall Comments

- ❑ Current four-step model structure still valid approach.
- ❑ Some modeling steps could be stratified further.
- ❑ The Commission's time-of-day assignment methodology would be considered advanced practice.

# List of Potential Improvements

Trip Generation	Consider incorporating workers per household and/or the presence of children to further stratify trip generation
	Consider using different method to define Bicycle/Walk friendly Area Type (I.E. intersection density, street grid)
	Consider developing a population synthesizer. This would assist in determining the number of workers and the presence of children
Trip Distribution	Consider developing a destination choice logit model
	Consider not using K factors
	<ul style="list-style-type: none"> <li>Consider using special generators instead of K-factors</li> <li>Consider stratifying trip distribution by income to better match high income households to high wage jobs</li> </ul>
	Consider incorporating the log sum from mode choice into trip distribution
Mode Choice	Consider skimming for each mode modeled in mode choice
	Consider performing mode choice by time-of-day
	Consider local, express, and rapid modes separately
Trip Assignment	Consider incorporating the time-of-day assignment into four-step model and feedback period travel times to mode-choice and, potentially trip distribution.
	Consider using passenger car equivalent (PCE) based capacities
	Consider pre-loading heavy-duty trucks and transit vehicles
	Consider using generalized cost in highway path building
	Consider stratifying assignment by vehicle class
	Consider using more than one volume-delay function stratified by facility type.
	Consider alternative volume delay functions such as the Akcelik or Conical functions rather than the BPR curve
	Consider assigning travel to park-and-ride lots
Other	Consider running the feedback loop more than once run to a relative gap of 0.001 based on travel time skims
	Consider a logit vehicle availability model
	Consider defining areas to be used in determining vehicle availability based on transit service
	To better address travel at the Region's fringe, consider generating total (Internal/External) travel by Region's residents and generating attractions for halo zones outside the Region.
	<ul style="list-style-type: none"> <li>Use socioeconomic data from other sources for halo zones (I.E. CMAP, WisDOT, and others)</li> <li>Push through trip distribution and mode choice</li> </ul>
	Consider using Quick Response Freight Manual methods to estimate commercial vehicle travel
	Consider linkages between statewide freight model and external commercial vehicle travel

# Major Differences From Current Model

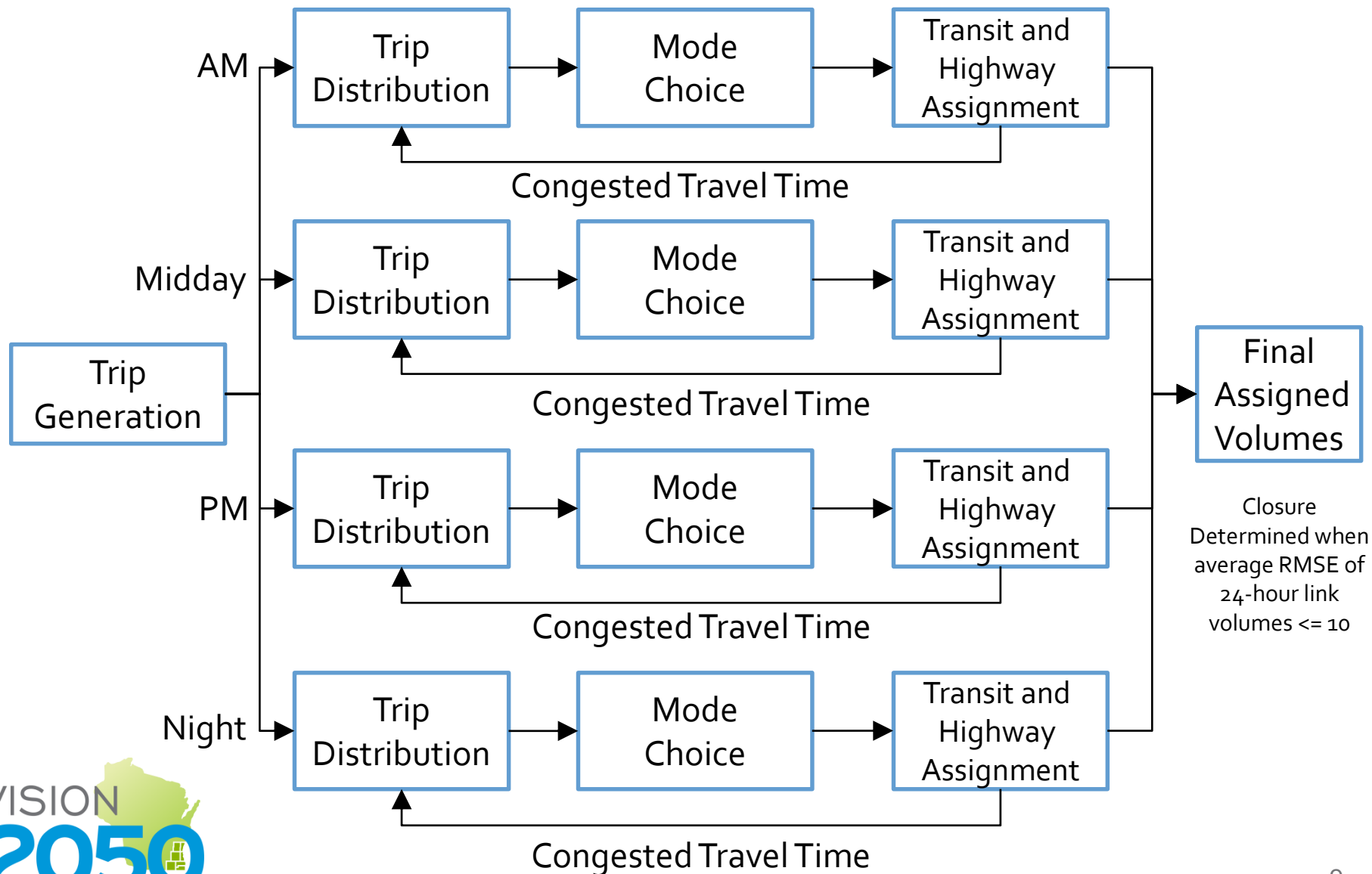
- ❑ Time-of-Day (AM, Midday, PM, Night)
- ❑ Trip Generation includes internal and external trips generated by a household.
- ❑ Trip Distribution for HBW, HBS, HBO, NHBW, and NHBO is now a destination choice model which considers the number as well as the quality of mode options in a zones attractiveness.
- ❑ Internal to External travel included in trip distribution step.
- ❑ Nonmotorized as modal option has been incorporated into mode choice

# Major Differences (continued)

- ❑ Commercial truck model developed based on Quick Response Freight Manual.
- ❑ Assignment by vehicle class (auto, transit, light-duty truck, medium-duty truck, heavy-duty truck)
- ❑ Use of passenger car equivalents as opposed to vehicles in capacity restraint
- ❑ Multiple volume delay functions based on facility type, capacity, and speed.
- ❑ Feedback has been enhanced by adding a criteria for reaching closure as opposed to a fixed number of iterations.



# GenV Travel Demand Model



# Trip Generation

- ❑ Cross-Classification Model (HBW, HBS, HBO, NHBW, NHBO)
  - Vehicle Availability (0, 1, 2, 3, 4+)
  - Household Size (1, 2, 3, 4, 5+)
  - Number of Workers (0, 1, 2, 3, 4+)
  - Age of Head of Household (16-44, 45-74, 75+)
  - Area Type (Urban, Suburban, Rural)
- ❑ Existing school trips by mode factored based on growth in projected households

# Trip Generation (continued)

- ❑ Existing group quartered trips by mode factored based on growth in group quartered population.
- ❑ Internal and internal to external commercial vehicle travel generated using trip generation rates:
  - Light-Duty, Medium-Duty, and Heavy-Duty Truck Trips Modeled.
  - Based on FHWA Quick Response Freight Manual (QRFM) methodology, adjusted to reflect survey data.
- ❑ External to internal and thru commercial truck travel factored up based on Freight Analysis Framework (FAF) forecasts.

# Trip Distribution

- ❑ Destination choice model for HBW, HBS, HBO, NHBW, and NHBO purposes. Sensitive to:
  - Modes available (mode choice logsums)
  - Attractions
  - Distance
  - Intrazonal trip
  - Commercial vehicle model uses a standard gravity model for each vehicle class.

# Mode Choice

- ❑ Transit, nonmotorized (walk and bike), and auto modes modeled as choices. Sensitive to:
  - Time (in-vehicle, out-of-vehicle)
  - Cost (per mile, fare, parking)
  - Walk/bike distance
  - Vehicle availability
  - Area type (urban, suburban, rural)
  - Intrazonal trip

# Mode Choice (continued)

- ❑ HBW, HBS, and HBO trip purposes and nested logit structure is used.
- ❑ NHBW and NHBO trip purposes use a multinomial structure.

# Vehicle Occupancy

- ❑ Zonal average purpose specific vehicle occupancy factors are created based on the household characteristics specific to each traffic analysis zone.
  - Vehicle availability
  - Household size
- ❑ Vehicle occupancy can be further adjusted through application of regional average vehicle occupancy factors by purpose (HBW, HBS, HBO, NHBW, NHBO).

# Trip Assignment

- ❑ Auto and transit assignment both used the same highway network.
  - Transit consumes capacity on the highway network.
  - Transit travel times take into account congestion on highway network.
- ❑ Capacity is modeled as passenger car equivalents (PCE)
  - Potential to more accurately reflects the impact different vehicle classes have on the congestion of the links they are assigned on.



# Trip Assignment (continued)

- ❑ Application of multiple volume-delay functions (VDF).
  - Four freeway VDFs based on the free-flow speed
  - Four surface arterial VDFs based on the free-flow speed and number of lanes
- ❑ Effect of ramp metering can now be modeled through modification of ramp capacities by period.

# Feedback

- ❑ Each of the four period assignments (AM, midday, PM, and night) are combined and compared to an average of the previous iterations to determine if the travel demand model has stabilized.
- ❑ Closure is determined if the RMSE of the current iteration is less than or equal to 10 as compared to the MSA of the previous iterations.
- ❑ The maximum number of iterations the model is allowed to run is 20.

# Validation: Vehicle Availability

## COMPARISON OF CENSUS AND MODEL-ESTIMATED PERSONAL USE VEHICLE AVAILABILITY BY COUNTY

County	2006-2010 Census Transportation Planning Package Estimate	Travel Demand Model Estimate	Percent Difference
Kenosha	114,600	110,375	-3.7
Milwaukee	553,250	572,355	3.5
Ozaukee	66,765	67,505	1.1
Racine	135,560	132,960	-1.9
Walworth	77,300	77,665	0.5
Washington	104,245	101,540	-2.6
Waukesha	303,585	295,150	-2.8
Region	1,355,305	1,357,550	0.2

# Validation: Household Size

## COMPARISON OF CENSUS- AND MODEL-ESTIMATED PERCENTAGE OF HOUSEHOLDS BY VEHICLES AVAILABLE AND HOUSEHOLD SIZE WITHIN SOUTHEASTERN WISCONSIN: 2011

Vehicles Available	2006-2010 Census CTPP Estimate					Travel Demand Model Estimate				
	Household Size				Total	Household Size				Total
	One	Two	Three	Four or More		One	Two	Three	Four or More	
None	6.0	1.7	0.9	0.9	9.5	5.0	1.5	0.7	1.4	8.7
One	20.8	8.0	3.6	3.4	35.8	19.0	7.4	4.0	5.4	35.8
Two	2.9	19.0	6.2	10.3	38.4	3.2	19.0	6.7	9.2	38.2
Three	0.5	3.4	3.7	4.1	11.7	0.4	4.5	3.3	4.2	12.4
Four or More	0.3	0.9	0.9	2.5	4.6	0.4	1.2	1.1	2.3	5.0
Total	30.5	33.0	15.3	21.2	100.0	28.0	33.5	15.9	22.6	100.0

# Validation: Trip Generation

## COMPARISON OF TRAVEL SURVEY AND MODEL ESTIMATED PERSON TRIPS WITHIN THE REGION: 2011

Trip Purpose	2011 Travel Survey Estimated	GenV Travel Demand Model Estimated	Percent Difference
Home-Based Work	1,380,000	1,402,500	1.6
Home-Based Shopping	755,900	757,000	0.1
Home-Based Other	1,963,500	1,926,800	-1.9
Nonhome-Based Work	611,400	619,100	1.3
Nonhome-Based Other	888,500	883,300	-0.6
Average	5,599,300	5,588,700	-0.2

# Validation: Trip Distribution

## COMPARISON OF TRAVEL SURVEY AND MODEL ESTIMATED PERCENT INTRAZONAL TRIPS WITHIN THE REGION: 2011

Trip Purpose	2011 Travel Survey Estimated			Travel Model Estimated			Difference in Percent Intrazonal Trips
	Total Trips	Intrazonal Trips	Percent Intrazonal Trips	Total Trips	Intrazonal Trips	Percent Intrazonal Trips	
Home-Based Work	1,343,000	37,000	2.8	1,366,200	36,300	2.7	-0.1
Home-Based Shopping	715,200	40,700	5.7	716,500	40,500	5.7	0.0
Home-Based Other	1,832,300	131,200	7.2	1,796,500	130,300	7.3	0.1
Nonhome-Based Work	579,200	32,200	5.6	586,700	32,400	5.5	-0.1
Nonhome-Based Other	804,100	84,400	10.5	799,800	83,500	10.4	-0.1
Total	5,273,800	325,500	6.2	5,265,700	323,000	6.1	-0.1

# Validation: Trip Distribution (continued)

## COMPARISON OF TRAVEL SURVEY AND MODEL ESTIMATED AVERAGE TRIP LENGTH FOR INTERNAL RESIDENT HOUSEHOLD PERSON TRAVEL WITHIN THE REGION: 2011

Trip Purpose	2011 Travel Survey Estimated Trip Length		Travel Model Estimated Trip Length		Percent Difference	
	Minutes	Miles	Minutes	Miles	Minutes	Miles
Home-Based Work	17.9	10.4	18.1	10.4	1.1	0.0
Home-Based Shopping	9.1	4.5	8.9	4.4	-2.2	-2.2
Home-Based Other	10.5	5.4	10.2	5.4	-2.9	0.0
Nonhome-Based Work	13.7	7.3	12.8	7.2	-6.6	-1.4
Nonhome-Based Other	9.6	4.7	9.4	4.7	-2.1	0.0
Average	12.4	6.7	12.3	6.7	-0.8	0.0

# Validation: Mode Share

## COMPARISON OF TRAVEL SURVEY AND MODEL ESTIMATED AVERAGE WEEKDAY MOTORIZED AND NON-MOTORIZED TRIPS BY TRIP PURPOSE: 2011

Trip Purpose	2011 Auto Trips			
	Travel Survey Estimate	Travel Model Estimate		
		Number	Difference from Survey	Percent Difference
Home-based work	1,276,700	1,319,200	42,500	3.3
Home-based shopping	640,800	648,900	8,100	1.3
Home-based other	1,683,700	1,681,000	-2700	-0.2
Nonhome-based work	546,000	559,800	13800	2.5
Nonhome-based other	752,900	765,400	12500	1.7
Total	4,900,100	4,974,300	74,200	1.5

Trip Purpose	2011 Transit Trips			
	Travel Survey Estimate	Travel Model Estimate		
		Number	Difference from Survey	Percent Difference
Home-based work	34,200	35,600	1,400	4.1
Home-based shopping	12,700	13,000	300	2.4
Home-based other	23,500	23,800	300	1.3
Nonhome-based work	8,100	7,700	-400	-4.9
Nonhome-based other	14,200	14,300	100	0.7
Total	92,700	94,400	1,700	1.8

Trip Purpose	2011 Non-Motorized Trips			
	Travel Survey Estimate	Travel Model Estimate		
		Number	Difference from Survey	Percent Difference
Home-based work	69,200	71,400	2,200	3.2
Home-based shopping	64,100	63,900	-200	-0.3
Home-based other	131,000	136,800	5800	4.4
Nonhome-based work	33,200	35,900	2700	8.1
Nonhome-based other	42,800	35,200	-7600	-17.8
Total	340,300	343,200	2,900	0.9



# Validation: Vehicle Miles of Travel

## COMPARISON OF MODEL ESTIMATED AND TRAFFIC COUNT ESTIMATED ARTERIAL SYSTEM VEHICLE-MILES OF TRAVEL ON AN AVERAGE WEEKDAY IN THE REGION: 2011

County	Estimated 2011 Average Weekday Vehicle-Miles of Travel from Traffic Counts (thousands)	Travel Demand Model Estimated 2011 Average Weekday Vehicle- Miles of Travel (thousands)	Percent Difference
Kenosha	3,497	3,227	-7.7
Milwaukee	16,210	14,744	-9.0
Ozaukee	2,378	2,391	0.6
Racine	3,468	3,902	12.5
Walworth	2,452	2,924	19.2
Washington	3,442	3,700	7.5
Waukesha	9,415	9,962	5.8
Region	40,862	40,849	<0.1

# Validation: Traffic Assignment

## ROOT MEAN SQUARED ERROR COMPARISON OF MODEL ESTIMATED AVERAGE WEEKDAY TRAFFIC ASSIGNMENT RELATIVE TO ESTIMATED ACTUAL COUNT BY COUNT VOLUME RANGE

Average Weekday Traffic Count Volume Range	Number of Links	Root Mean Squared Error (RMSE)	Percent RMSE (Target)	Percent RMSE (Actual)
0 to 4,999	3,608	1,595	100.0	63.1
5,001 to 9,999	1,742	2,931	45.0	41.7
10,000 to 14,999	500	4,050	35.0	33.4
15,000 to 19,999	210	5,333	30.0	31.3
20,000 to 29,999	95	7,014	27.0	30.1
30,000 to 39,999	43	5,940	25.0	16.7
40,000 to 49,999	35	5,843	25.0	13.2
50,000 to 59,999	25	8,120	20.0	14.7
Greater than 60,000	78	5,386	19.0	7.7
Average	6,336	2,798	45.0	41.1

# Validation: Traffic Assignment (continued)

## COMPARISON OF TRAFFIC COUNT AND MODEL ESTIMATED AVERAGE WEEKDAY TRAFFIC ON ARTERIAL STREETS AND HIGHWAYS WITHIN SOUTHEASTERN WISCONSIN:2011

