REIMAGINED

MOVE2040

APPENDIX 13:

TRAVEL DEMAND MODEL

WICHITA AREA METROPOLITAN PLANNING ORGANIZATION

271 W 3RD STREET, STE. 208, WICHITA, KS 67202

316-779-1313 | WWW.WAMPO.ORG

Introduction

The Wichita Area Metropolitan Planning Organization (WAMPO) and member jurisdictions use the WAMPO Regional Travel Model (WAMPO Model) as a tool to forecast traffic and travel in Sedgwick County and portions of Sumner and Butler Counties. The primary purpose of the travel model is to support the metropolitan transportation plan (MTP). In addition, the model can support evaluation of proposed roadway projects, help evaluate potential impacts of proposed development projects, and support various other studies of the region, subareas, corridors, and other planning activities. The Kansas Department of Transportation (KDOT) makes use of the travel model to support studies related to improvements on the state highway system. The model has been calibrated to reflect a base year of 2017 and contains future year data reflecting forecast 2045 conditions. This model update builds on the previous model update which had a base year of 2010 and included a household travel survey, a commercial vehicle survey, an external station survey, and on-board transit survey. Parameters remain consistent with the previous model update unless adjustment to match the new 2017 base year traffic counts was required. The WAMPO Model is an adaptation of the standard 4-step modeling process that is common in many small and medium-sized communities in the United States. A flow chart of the model is shown in Figure I.1.

Coordination and Outreach

WAMPO established a Model Validation Task Force at the beginning of the travel model update process. The Task Force consisted of representatives from area cities and agencies who were familiar with the transportation system within their jurisdictions. As the model update progressed, this group met periodically to review model results and provide invaluable input. Maps were generated at the various stages to enable Task Force members to review the various stages of the process. Input on the following was obtained:

Traffic Analysis Zone structure and allocation with special attention to the expanded boundary areas;

Roadway network characteristics such as speed limit and number of lanes; and,

Roadway traffic counts and corresponding model generated traffic volumes.

This executive summary and the companion WAMPO Regional Travel Demand Model: Technical Documentation contain background information on the model itself and the process that was followed to ensure the results generated are reasonable. Detailed model validation was performed using observed traffic count data and other travel information from WAMPO surveys.

In addition to the Model Validation Task Force, WAMPO worked with Wichita Transit to ensure the bus system included in the WAMPO Model was reflective of the current level of service provided to Wichita transit users.

The socio-economic data used to provide population and employment allocations throughout the WAMPO model area was obtained from the US Census, American Community Survey, and employer databases. The original base year (2010) data was updated to base year 2017. The 2010 base data was based on similar data originally, and also during the time the 2010 WAMPO model was being updated, Wichita and the surrounding communities were working on a Community Investment Planning initiative. This data was still the base growth areas and assumptions, but reflected changes that had occurred since the 2010 based on aerial photo changes and available commercial and residential changes identified from building permits from the planning department. This work included a detailed review of land use trends and employment allocation into the future. The forecast year demographic data used in the model is based on the results of this effort.

Uses and Outputs

The traditional use of a travel demand model is to evaluate systematic congestion on the regional roadway system and provide a tool for considering improvements. Fortunately for the Wichita region, the level of system wide roadway congestion is minimal under both the base and forecast year conditions. Congestion worsens in some portions of the system and the WAMPO model can provide appropriate output data to assist in identifying these areas. Maps similar to those used by the Task Force can depict roadway level of service under different planning scenarios. Comparison of these among scenarios reveals the congestion changes. This provides a useful planning tool for analysis of WAMPO's long range plan scenarios as both the impacts of roadway network changes and demographic growth or reallocation are demonstrated by the resulting shifts in travel.

The WAMPO Model can provide a variety of outputs to demonstrate these travel results. The maps in Figures I.2 through I.5 show some examples of information that can be extracted from the model. Access to various key areas in the region can by shown by the travel time data presented in Figures I.2 and I.3. Level of service on the roadway system is shown in Figure I.4 and Figure I.5. As different scenarios are considered, these diagrams can be regenerated and compared to identify key outcomes.

	2017	2040
Vehicle-Miles Traveled (VMT)	13,704,531	21,107,922
Vehicle-Hours Traveled (VHT)	720,257	1,125,035
PM Peak Delay per Trip	31s	84s

Table 1.0 Model Output Summary

	2017	2040
Population	559,777	757,747
Households	219,765	324,945
Employment	316,692	383,295

Table 1.1 Model Demographic Assumptions Summary

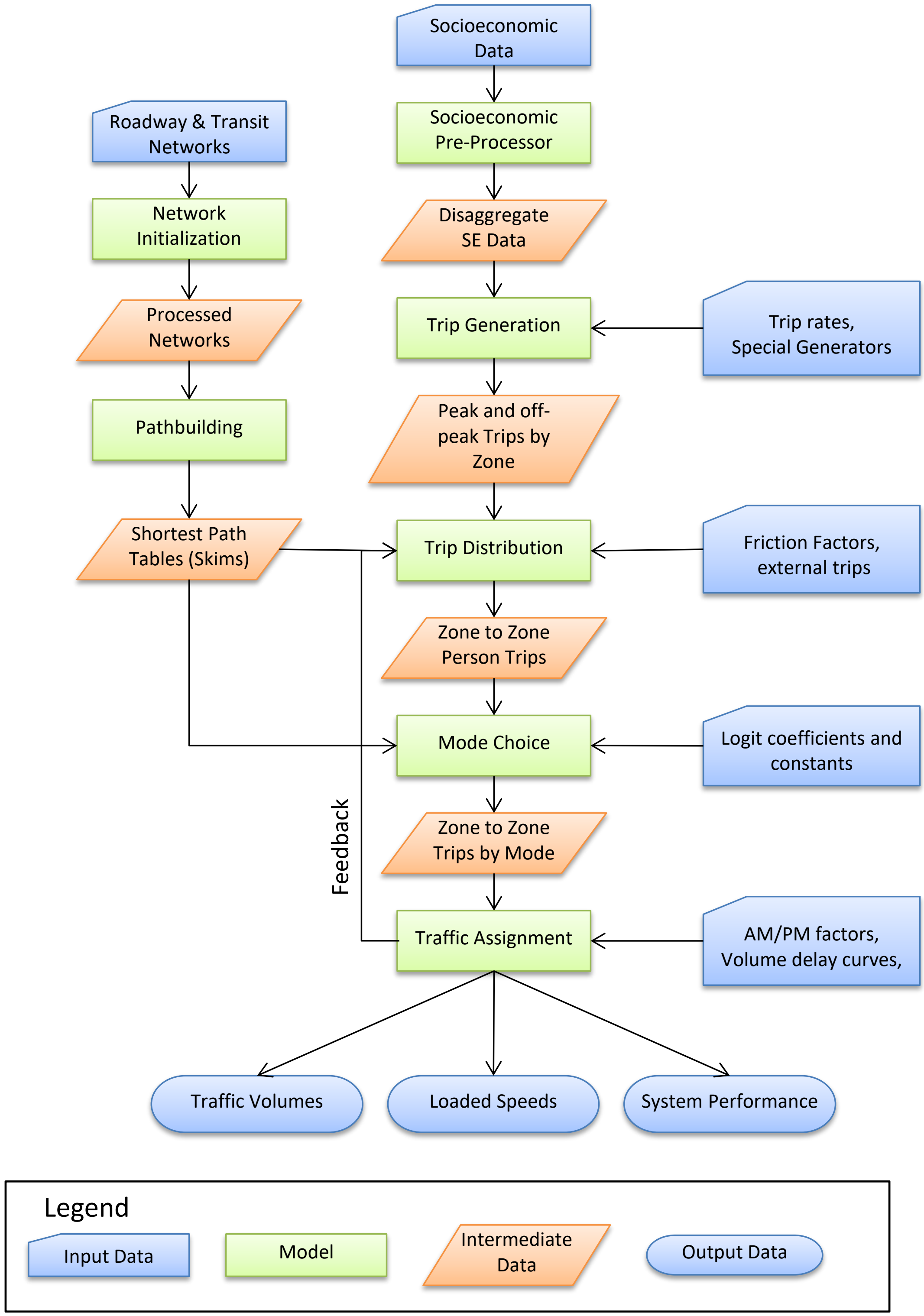

Figure I.1 Model Flow Chart

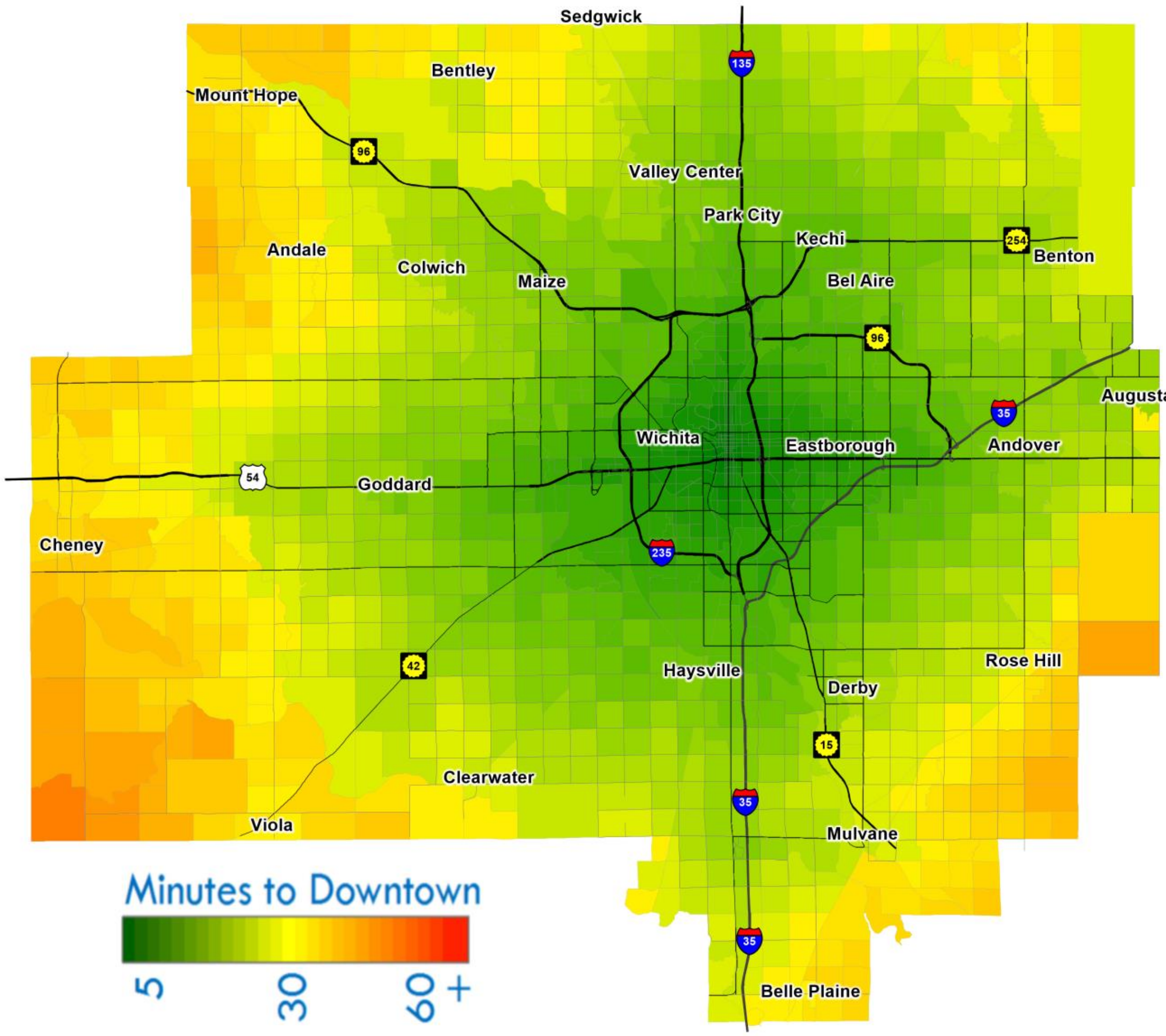

Figure I.2 Drive time to Downtown

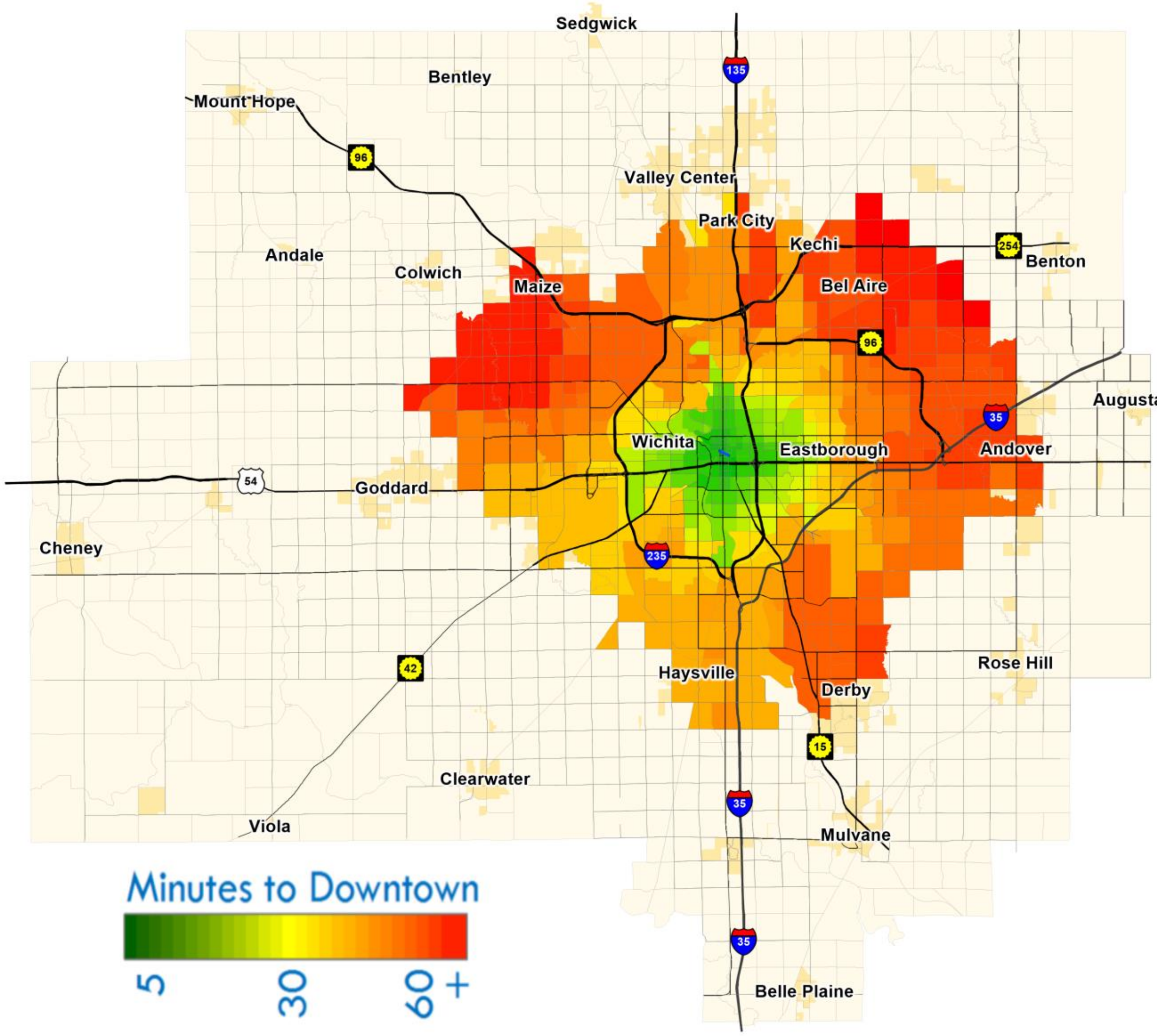

Figure I.3 **Bus time to Downtown**

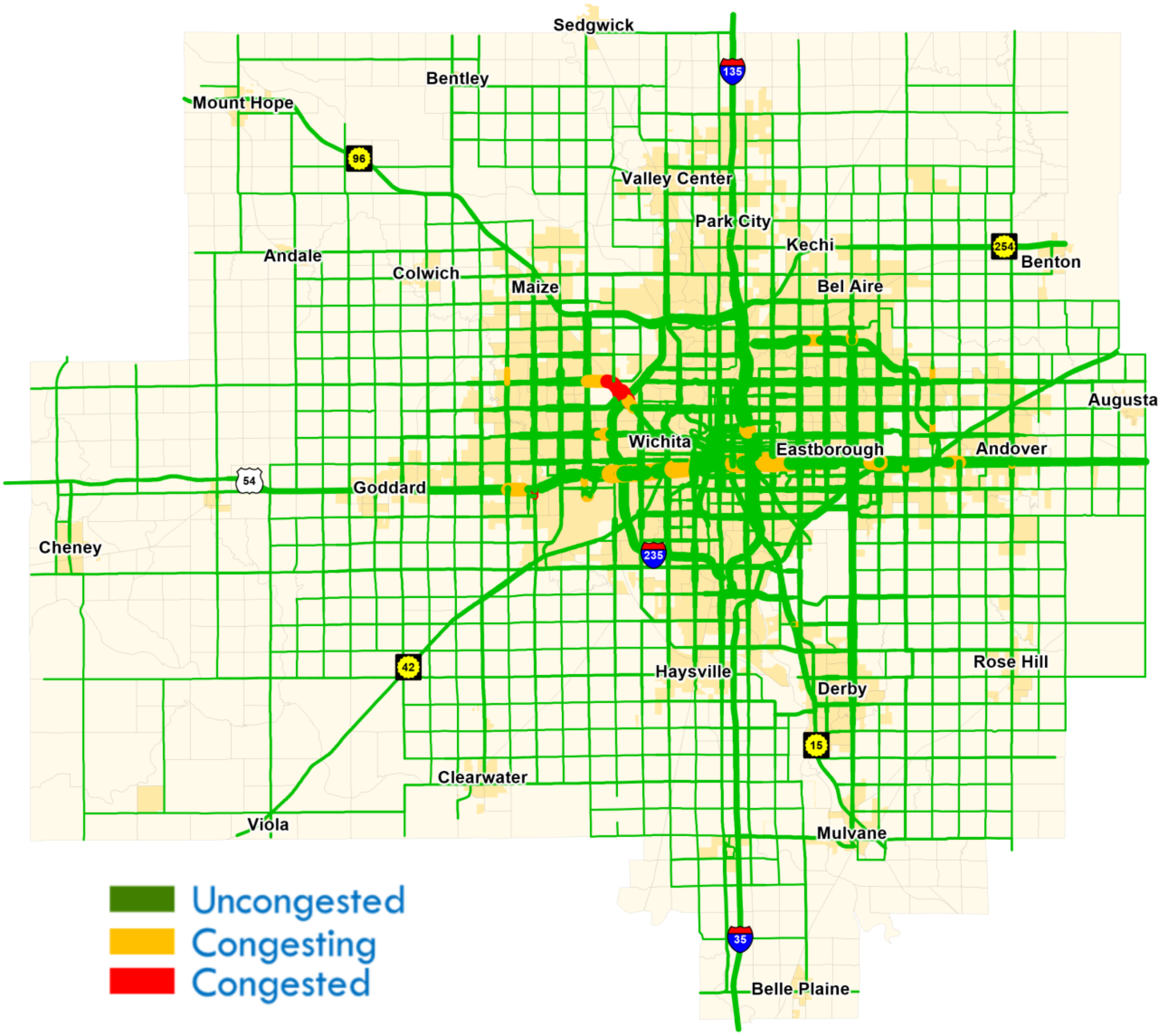

Figure I.4 2017 Roadway Level of Service

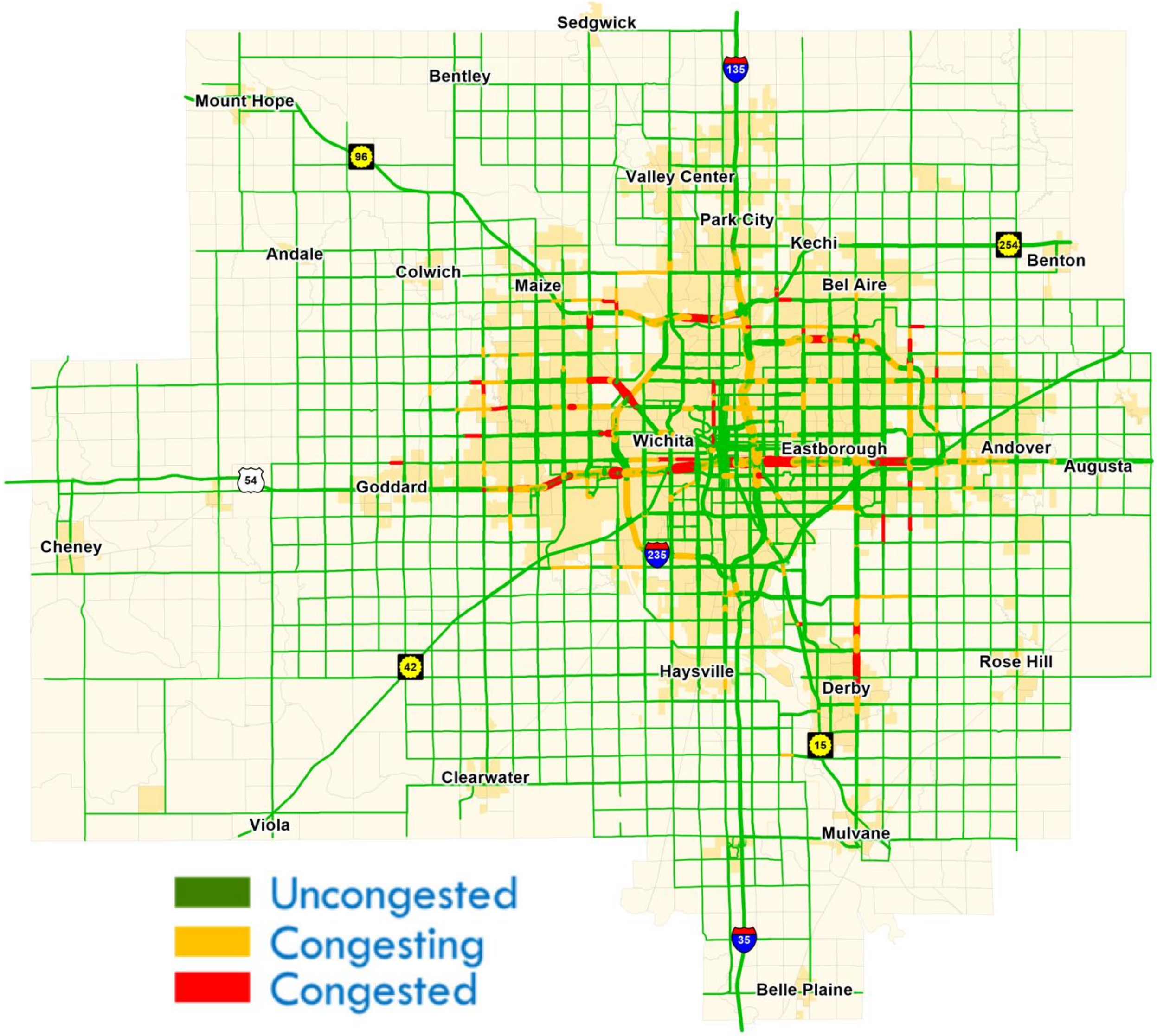

Figure I.5 2040 Roadway Level of Service

Input Data

One of the critical components of any travel model is the input data. For the WAMPO Model, this includes roadway and transit networks, socioeconomic data and other factors (i.e. coefficients, peak hour factors and external trip data). This input data describes the travel condition for the WAMPO region and provides the foundation for evaluating system performance and future travel alternatives.

The roadway network contains basic input information for use in the travel model and is used to distribute person trips and route vehicle trips throughout the region. Input network attributes used by the travel model include facility type, area type, number of lanes, speed limit, and direction of flow. The facility type or functional classification assigned to the various roadways in the network follow the definitions shown in Table 1.1. Corresponding capacities and speeds for each facility type are also assigned and then refined as the network is processed through the various modeling steps shown above.

ID	Facility Type
1	Interstate/Freeway
2	Expressway
3	Principal Arterial
4	Minor Arterial
5	Collector
6	Minor Collector
7	Frontage Road
8	Ramp
9	High Speed Freeway to Freeway Ramp
10	Toll Road
11	HOV Lanes (Not currently present, included for expandability)
50	Transit Only Link
98	Transit walk access connector *automatically generated - only present in the output transit line layer*
99	Centroid Connector

Table 1.3 Facility Types

The travel model uses transit networks to build shortest transit paths between each zone pair, as well as to assign transit trips to individual transit routes. The WAMPO Model uses information stored on the roadway network and a model version of the Wichita Transit bus routes to represent the transit system. Routes and the associated service characteristics are converted into a series of links and nodes or stops. Transit networks are separate but connected to the roadway network and it is important to maintain this consistency when using the WAMPO Model. A listing of the routes included in the base year WAMPO Model network and the corresponding headway assumptions are listed in Table 1.4. A description of this relationship and the transit network development process is contained in the Technical Documentation.

Route	Peak Headway (minutes)	Off-peak Headway (minutes)
11 - West Maple	30	30
12 - West Central	30	30
13 - North Broadway	30	60
14 - Meridian	30	60
15 - Riverside	30	60
16 - South Seneca	30	60
17 - North Waco	60	60
21 - East 17th	30	30
22 -East Harry	30	30
23 - South Broadway	30	60
24 - College Hill	30	60
25 - East Central	30	60
26 - South Main	30	60
27 - East 13th	60	60
28 - North Grove	0	60
29 - East Lincoln	60	60
201 - Rock Road	60	60
0 - Q-Line	10	10

Table 1.4 Route Headway Assumptions

Trip Generation

Trip generation is the first phase of the traditional 4-step travel demand modeling process. It identifies the trip ends (productions and attractions) that correspond to the places where activities occur as represented by socioeconomic data (e.g., households, employment). Productions and attractions are estimated for each Traffic Analysis Zone (TAZ) by trip purpose, and then balanced at the regional level so that total productions and attractions are equal. In some cases, production and attraction allocation sub-models are applied to better represent the geographic distribution of trip-ends. The resulting productions and attractions by trip purpose and TAZ are subsequently used by the Trip Distribution model to estimate zone-to-zone travel patterns.

Trips are generated by purpose and income group, derived from the Home Interview Survey conducted in the Fall 2010 through Spring 2011. This survey collected data about travel behavior of

Wichita area residents and was collected specifically to support development of the 2010 base year WAMPO travel model. The survey includes responses from 3,376 randomly selected households, as well as 200 additional samples collected from traditionally underserved populations in the region[1]. Additional discussion of the survey and the processing involved to develop the WAMPO travel model characteristics is included in the Technical Documentation.

There are four income groups (low, medium, medium-high and high) and five trip purposes used in the WAMPO Model as listed below:

Home-Based Work (HBW): Trips between a traveler's residence and workplace.

Home-Based Shop (HBS): Shopping trips starting or ending at the traveler's residence.

Home-Based Other (HBO): All remaining trips starting or ending at the traveler's residence.

Work-Based Other (WBO): Trips starting or ending at the workplace, but with neither end at the traveler's residence.

Other-Based Other (OBO): Trips that do not start or end at the traveler's residence or workplace.

The trip generation model uses zone level average income group and household size to generate trips. A cross-classification model based on these two characteristics was developed using the home interview survey data, details of which are contained in the Technical Documentation. Cross-classification is a commonly used approach for a trip based trip generation model.

The WAMPO model also generates trips for commercial and truck trips. The trip rates for used for these trips were derived from a 2008 commercial vehicle survey performed by the Community Planning Association of Southwest Idaho (COMPASS) Area.

In addition to the internal-internal trips that occur entirely within the modeling area, the model also includes travel from outside the region, called external travel. Trips with one end inside the modeling area and the other outside of the area are called internal-external (IE) trips. Through trips, or external-external (EE) trips, are those that pass through the modeling area without stopping or with only short convenience stops. External travel is modeled explicitly at the 37 external stations where roadways cross the model area boundary. This external trip component of the WAMPO Model is based on an external station survey conducted in 2012.

Trip Distribution

Trip distribution is the second phase of the traditional 4-step demand model. Trip distribution is the process through which balanced person trip productions and attractions from the trip generation model are apportioned among all zone pairs in the modeling domain. The resulting trip matrix contains both intrazonal trips (e.g., trips that don't leave the zone) and interzonal trips to all other zone interchanges for each trip purpose.

The WAMPO Model uses a gravity model equation and applies friction factors to represent the effects of impedance between zones. As the impedance (i.e., travel time) between a pair of zones

[1] 2011 WAMPO Regional Household Travel Survey, Final Report, ETC, July 2011.

increases, the number of trips between the zone pair decreases as represented by a decreasing friction factor. This is similar to the standard gravity model which assumes that the gravitational attraction between two bodies is directly proportional to their masses. The trip distribution model makes a similar assumption in that the number of trips between two zones is directly proportional to the number of productions and attractions contained in those zones. The gravity model used by trip distribution to estimate the number of trips between each zone pair is defined in the equation below.

$$T_{ij} = P_i \cdot \frac{A_j \cdot F_{ij} \cdot K_{ij}}{\sum_j A_j \cdot F_{ij} \cdot K_{ij}}$$

Where:

T_{ij} = trips from zone i to zone j
P_i = productions in zone i
A_i = attractions in zone j
K_{ij} = K-factor adjustment from i to zone j
i = production zone
j = attraction zone
F_{ij} = friction factor (a function of impedance between zones i and j)

Friction factors represent the impedance to travel between each zone pair. Friction factors have been calibrated for each trip purpose based on a trip length frequency distribution (TLFD) generated from WAMPO household survey data and roadway network shortest path matrices.

Peak and Off-Peak Period Definitions

Trips occurring during the AM and PM peak hours are distributed based on peak congested speeds and trips occurring during off-peak times are distributed based on off-peak congested speeds. Trip distribution is performed in Production-Attraction (PA) format rather than Origin-Destination (OD) format. This is because the majority of trips in the AM peak hour travel from production to attractions (e.g., to work) and the majority of trips in the PM peak hour travel from attraction to productions (e.g., from work).

The WAMPO Model has the capability of generating trips by time of day, using factors representing the portion of trips occurring in the peak (combined AM and PM peak hours) and off-peak (all other times) period. Peak hour trips are further separated in the time of day step prior to traffic assignment. To accomplish this, time of day factors were estimated based on the WAMPO household survey. The resulting share of trips in the peak by trip purpose are shown in Table 3.1.

Time Period	HBW	HBS	HBO	WBO	OBO
Peak *7:00 – 8:00 AM and 5:00 – 6:00 PM*	30.4%	14.7%	24.5%	17.3%	14.2%
Off-Peak *All other times*	69.6%	85.3%	75.5%	82.7%	85.8%

Table 3.1 Peak and Off-Peak Trip Percentages by Purpose

Roadway Network Shortest Path

The impedance portion of the gravity model equation is based on shortest paths between each zone pair. The WAMPO Model finds the shortest path between each zone pair based on peak or off-peak congested travel time. Peak travel time is defined as the AM peak hour directional travel time, while off-peak travel time is defined as the off-peak period congested travel time. In the first speed feedback iteration, peak travel times are calculated based on congested speed lookup tables developed from INRIX and travel survey data. Initial off-peak speeds are identical to free flow speeds. In subsequent speed feedback iterations, travel times are calculated based on traffic assignment using a method of successive averages as described further in the traffic assignment section of the Technical Documentation.

The pathbuilding, terminal time, and intrazonal impedance procedures described in the Technical Documentation generate an estimated travel time for each zone pair in the travel model. This information is based on posted speed data, along with conversion factors described in the Roadway Network section of the WAMPO Model Technical Documentation. The resulting travel times were validated against the household survey data by comparing modeled travel times to trip durations reported in the household survey. For the previous model update, validation was performed by evaluating the differences in reported vs. modeled travel times. This analysis showed that 74% of the records in the peak period and 77% of the records in the off-peak period show modeled travel times with less than a 5 minute difference from the reported times. This confirms the model generated travel times are reasonable and suitable for use with this planning tool. Pathbuilding and travel time parameters used in this model update remain consistent with those derived for the previous model.

Friction Factors

Friction factors represent the impedance to travel between each zone pair. The WAMPO Model applies the friction factors in the form of gamma functions for each trip purpose. The gamma function is defined by the equation below.

$$F_{ij} = \alpha t^{-\beta} e^{-\gamma t}$$

Where:

F_{ij} = Friction factor between zones i and j

t = travel time

α, β, γ = calibration parameters

Friction factors for each trip purpose were calibrated by comparing a Trip Length Frequency Distribution (TLFD) generated by the travel model to a TLFD generated from a combination of observed trip OD pairs and the travel model shortest path matrix. The travel model was run iteratively with minor adjustments to calibration parameters alpha, beta, and gamma until the modeled and observed TLFD converged to a similar shape. Observed and calibrated TLFD plots and friction factor plots are shown in the Technical Documentation.

A comparison of observed TLFDs for peak and off peak periods shows minimal differences between time periods for all trip purposes. Therefore, separate calibration exercises were not performed for the peak and off-peak time periods. A comparison of trip lengths by income group did show significant differences for HBW trips, but not for other trip purposes. Therefore, the HBW trip purpose was calibrated by income group, while other trip purposes were calibrated for all income groups combined.

Because locally specific commercial vehicle survey data is not available the commercial vehicle, medium truck, and large truck friction factors were set to the same values as the high income HBW friction factors. This set of friction factors was selected because it represents the longest observed average trip length.

Mode Choice

The WAMPO Model produces and distributes all person trips including non-motorized, carpool, and transit trips. The mode choice model separates the resulting person trip tables into the drive alone, shared ride (i.e., carpool), transit (walk access and drive access), and non-motorized (bicycle and walk) modes. Information about transit routes provides important input to the mode choice model. The mode choice model also considers trip lengths produced by the gravity model, resulting in sensitivity to higher density and mixed use areas.

The WAMPO mode choice model uses a nested logit formulation that takes transit service characteristics into account when predicting mode share. The resulting model is not limited to providing a representation of existing conditions, but instead can predict changes in transit ridership resulting from changes to transit service, demographics, and land use patterns.

Observed Mode Shares

The mode choice model has been calibrated to reproduce observed mode shares. Observed mode share values for auto trips and non-motorized trips are based on data from the 2010 household travel survey data. For transit trips, transit trip data was obtained from Wichita Transit, with information such as trip purpose and household income based on an on-board survey conducted in 2008[2]. The resulting mode share targets are shown by time period in Tables 4.1 and 4.2. These targets were used in calibration, comparing model estimated shares to observed.

Transit trip targets are shown as a total number of trips rather than a percent share of all trips. This allows direct use of transit boarding data provided by Wichita Transit. Wichita Transit reported an average of 7,826 daily boardings on weekdays in February, March, April, May, September, October, and November of 2010. According to the on-board survey, 19% of transit trips involved a transfer, resulting in a total of 6,340 average daily transit trips. The on-board survey also provides purpose and income distributions shown in Tables 4.3 and 4.4.

[2] 2008 Wichita Transit On-Board Survey Findings Report. TranSystems Corporation and ETC Institute. April 2008.

Trip Purpose	Transit Trip Target	Drive Alone Share	SR2 Share	SR 3+ Share	Walk Share	Bike Share
HBW (Low Income)	354	88%	7%	3%	1.2%	1.4%
HBW (Med Income)	35	86%	9%	3%	1.2%	1.4%
HBW (Med-High Income)	10	92%	4%	2%	1.2%	1.4%
HBW (High Income)	1	90%	5%	2%	1.2%	1.4%
HBS	231	46%	30%	19%	4.0%	1.0%
HBO	646	26%	31%	38%	4.0%	1.0%
WBO	13	90%	6%	2%	1.8%	0.2%
OBO	13	29%	42%	28%	1.8%	0.2%

Table 4.1 Peak Period Mode Share Targets

Notes: Transit trip targets are shown as total transit trips and non-transit targets are shown as the share of non-transit trips. The peak period is defined as 7:00-8:00 AM and 5:00-6:00 PM.

Trip Purpose	Transit Trip Target	Drive Alone Share	SR2 Share	SR 3+ Share	Walk Share	Bike Share
HBW (Low Income)	1,369	82%	11%	5%	1.2%	1.4%
HBW (Med Income)	135	90%	7%	1%	1.2%	1.4%
HBW (Med-High Income)	37	94%	3%	1%	1.2%	1.4%
HBW (High Income)	5	92%	4%	1%	1.2%	1.4%
HBS	894	50%	29%	17%	4.0%	1.0%
HBO	2,500	38%	29%	28%	4.0%	1.0%
WBO	50	83%	10%	5%	1.8%	0.2%
OBO	50	45%	29%	24%	1.8%	0.2%

Table 4.2 Off-Peak Period Mode Share Targets

Notes: Transit trip targets are shown as total transit trips and non-transit targets are shown as the share of non-transit trips.

Trip Purpose	Share of Transit Trips
HBW	31%
HBS	18%
HBO	51%

Table 4.3 Transit Trip Purpose Distributions

Note: Non home based trips were not identified in the survey but are assumed at 1% each WBO and OBO.

Household Income Group	Share of Transit Trips
Low ($0 – $29,999)	82.5%
Medium ($30K - $59,999)	8.2%
Medium-High ($60K - $99,999)	2.2%
High ($100K and higher)	0.3%
Not Provided	6.9%

Table 4.4 Household Income Distributions for Transit Riders

The mode choice model separates trips in vehicles into drive alone, shared ride 2 (i.e., 2 occupants in a vehicle), and shared ride 3+. For drive alone and shared ride 2, auto occupancy is explicitly defined as 1 and 2 occupants. For the shared ride 3+ mode, average vehicle occupancy is expected to be higher than 3 and has been computed based on the household travel survey data. Auto occupancy for trips in 3+ occupant vehicles are listed in Table 4.5, with overall average auto occupancy shown for reference. The average auto occupancy values for shared ride 3+ trips are used to convert person trips by travel model into vehicle trips for assignment to the roadway network.

Trip Purpose	Overall Average Auto Occupancy	Average Auto Occupancy (SR 3+)
HBW	1.1	3.8
HBS	1.8	3.7
HBO	2.2	3.7
WBO	1.2	3.5
OBO	2.0	3.7

Table 4.5 Average Auto Occupancy by Trip Purpose

Mode Choice Model Structure

The WAMPO mode choice model has been asserted based on guidance from the Federal Transit Administration (FTA) and experience with mode choice modeling in other regions. The asserted approach eliminates the need for extensive data collection and estimation efforts. While model estimation is often useful in large metropolitan areas with extensive transit service, the asserted approach is considered more appropriate for an area with moderate transit service such as the Wichita area.

The WAMPO Model includes a nested logit mode choice model that addresses both motorized and non-motorized modes. Nested logit models represent the current best practice for mode choice modeling. The structure of the WAMPO mode choice model is shown in Figure 4.3. This structure first separates motorized trips from non-motorized trips, then separates auto and transit trips. Transit trips are further separated into local and premium service, and then and walk and drive access. Auto trips are further separated into drive alone, shared ride 2, and shared ride 3+.

The premium transit mode included in the WAMPO mode choice model represents potential future service. The premium mode serves as a placeholder for express, regional, BRT, or rail service that can be tested using the WAMPO mode choice model. A premium mode would feature significantly different service characteristics when compared to the existing local bus system. For example, a BRT service might feature low floor busses, ticket machines, and high quality stations with adequate seating and lighting. These features can be included in a more favorable alternative specific constant to represent features of a proposed service that are not included in travel time and cost values.

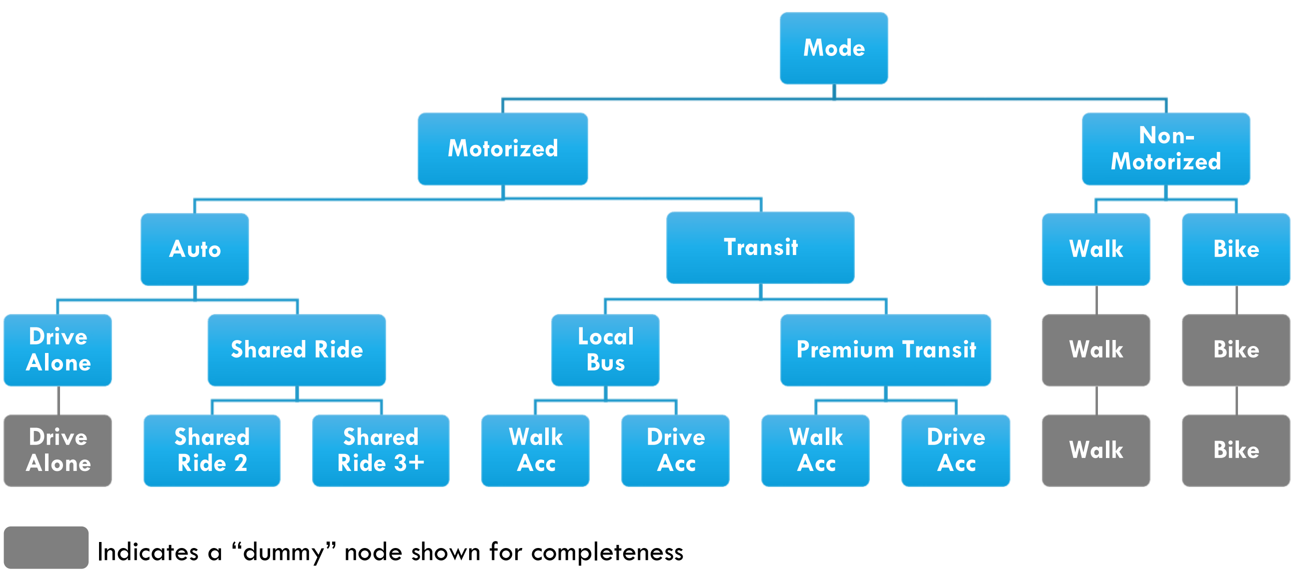

Figure 4.3 WAMPO Mode Choice Nesting Structure

As described previously, mode specific utility functions are used to describe the characteristics for each mode as shown in Table 4.6. Each of these characteristics is included with an associated coefficient that reflects the significance for that mode and travel group. For example, auto modes generally include a terminal time, drive time, and auto operating cost where transit modes include time spent traveling to and from transit stops, time waiting for a bus, time spent in the transit vehicle, and transit fare.

The observed ridership values noted previously were used to also calibrate Alternative Specific Constants for the Mode Choice Model. These values further distinguish between modes and local user preferences. Detailed discussion of the WAMPO Mode Choice Model and the values of all coefficients, nesting coefficients and alternative specific constants is contained in the Technical Documentation.

Mode	Walk	Bike	Drive Alone	SR2	SR3	Transit Walk	Transit Drive
Non-Motorized Time	✓	✓					
Operating Cost			✓	✓	✓		
Terminal Time			✓	✓	✓		
In-Vehicle Time			✓	✓	✓	✓	✓
Drive Access Time							✓
Walk Access/Egress Time						✓	✓
Short initial wait (1)						✓	✓
Long initial wait (1)						✓	✓
Transfer wait						✓	✓
Number of transfers						(2)	(2)
Transit Fare						✓	✓
Destination CBD				(2)	(2)	(2)	(2)
Destination Density				(2)	(2)	✓	✓

Table 4.6 Utility Specifications

Notes: (1) Short initial wait time includes the first 7.5 minutes, while long initial wait time includes any initial wait over 7.5 minutes.
(2) These terms are included in the model setup but are currently set to zero.

Trip Assignment

The trip assignment model includes a time of day step followed by assignment of transit and vehicle trips to the transportation networks. In the time of day model component, the vehicle trip tables from the mode choice model are converted to Origin/Destination format and factored into time periods for assignment on the roadway network.

In the traffic assignment step, vehicle trip tables by time of day are assigned to the roadway network using an equilibrium procedure for the AM and PM peak hours and for the off-peak period. After traffic assignment is completed, resulting travel times are fed back to trip distribution and the model is run iteratively until speeds input to trip distribution are reasonably consistent with speeds resulting from traffic assignment.

After speed feedback has been completed, transit person trips are assigned to the transit route system. Transit trips are assigned separately for peak and off-peak periods and by drive and walk access. These individual assignment results are combined to form daily transit assignment results.

Time of Day

Based on the analysis of household survey data and discussions with WAMPO staff, the AM and PM peak hours were defined as shown in Table 5.1. The peak hour definitions are consistent with the traditional morning and evening peaks observed in many similarly sized areas. One-hour peaks are often modeled in regions that don't experience significant congestion outside of rather short peak periods during typical weekdays. One-hour peaks also facilitate reporting of the common performance measure of peak hour level of service.

Period Name	Period Definition
AM Peak Hour	7:00 AM – 8:00 AM
PM Peak Hour	5:00 PM – 6:00 PM
Off-Peak Period	All Remaining Time (22 hours)

Table 5.1 Peak Period Definitions

Time of day processing is done in two steps in the WAMPO model. Factors are first applied in a pre-distribution time of day module that separates trips into peak and off-peak time periods but does not distinguish between different directions. After mode choice is complete, a second time of day process separates peak period trips into AM and PM trips and processes trip directionality. These time of day factors, along with the directional trip factors by time period were derived from the household survey data and are shown in Table 5.2.

Time Period	Direction	HBW	HBS	HBO	WBO	OBO
AM Peak Hour	Depart	17.0%	2.0%	14.7%	1.3%	2.8%
	Return	0.3%	0.4%	1.2%	7.1%	2.8%
PM Peak Hour	Depart	0.7%	4.8%	3.6%	8.2%	4.4%
	Return	12.4%	7.4%	5.1%	0.7%	4.4%
Off-Peak	Depart	36.3%	35.6%	32.9%	51.4%	42.9%
	Return	33.2%	49.7%	42.6%	31.3%	42.9%

Table 5.2 Overall Time of Day Factors

Traffic Assignment

The Traffic Assignment step loads the travel demand represented by the vehicle trip tables onto the roadway network. The WAMPO Model features a user equilibrium assignment method that accounts for traffic congestion and the associated rerouting of trips to avoid congestion. The equilibrium assignment process minimizes the total travel time on the roadway network, representing a condition in which each highway user has perfect knowledge of traffic conditions in the region.

The impedance used for determining the shortest path in the Traffic Assignment step of the WAMPO Travel Model includes travel time and auto operating cost. When including variables in addition to travel time, a generalized cost function converts all variables to a consistent cost using a value of time, as demonstrated in the equation below.

$$Generalized\ Cost = Time \cdot ValueOfTime + OperatingCost$$

A volume-delay function represents the effect of increasing traffic volume on link travel time in the assignment process. The WAMPO Model uses the most common volume-delay function called the modified Bureau of Public Roads (BPR) function. The modified BPR function is shown below.

$$T_C = T_F\left(1 + \alpha\left(\frac{V}{C}\right)^{\beta}\right)$$

Where:

- T_C = Congested travel time
- T_F = Freeflow travel time
- V = Traffic volume
- C = Highway design capacity (i.e., upper limit level of service C capacity)
- α = Coefficient alpha (0.15)
- β = Exponent beta (4.0)

The coefficient alpha and the exponent beta are calibrated values that vary by facility type and area type. They were developed by monitoring link speed and VMT balance by facility type during the model validation process. The specific values can be found in the Technical Documentation.

Speed Feedback

The trip distribution and mode choice model steps rely on congested zone to zone travel time information to distribute trips and identify mode shares. The traffic assignment step produces estimated congested travel speeds based on traffic flows and application of the volume-delay function. The speeds input to trip distribution and mode choice are generally not consistent with the speeds output from traffic assignment. To rectify this inconsistency, results from traffic assignment are used to re-compute zone to zone travel times for input to trip distribution and mode choice. The model is re-run, and a comparison is then made between the initial and updated zone to zone travel times. If the travel times are not reasonably similar, the updated travel times are then fed back to trip distribution and mode choice. This process can be repeated iteratively until a convergence criterion or iteration limit is met.

Inclusion of a speed feedback process in the travel model can have interesting and desirable effects on the way the travel model represents the effects of network improvements in congested situations. Without speed feedback, overall regional travel demand remains constant regardless of the roadway network assumptions because trip distribution and mode choice patterns are not affected by changing congestion levels.

When speed feedback is added to the model, heavy congestion results in slower speeds, thereby leading to shorter trip patterns in areas with heavy congestion. As roadway improvements are added to the model, the associated capacity increase results in faster travel speeds as localized congestion decreases. The higher speeds result in longer trip lengths, which has the effect of incrementally increasing overall travel demand. In the mode choice model, slower roadway speeds typically result in slower transit speeds as well, minimizing the effect of speed feedback on transit results. Speed feedback has a more notable effect on transit results when modeling transit options that do not experience speed degradation as traffic congestion increases. Inclusion of speed feedback is most important from a mode choice perspective when using the model to test options such as BRT, rail, or even improvements such as transit signal prioritization or queue jumps.

Application of Speed Feedback for Alternatives Analysis

Speed feedback ensures travel time consistency within the entire modeling structure. It was conceived as a model enhancement in the early 1990's largely in response to environmental lawsuits, although it is good practice and now considered a necessity. Generally, speed feedback is most noticeable when modeling network changes that provide a significant travel time improvement, such as a new freeway in a developing area. These types of alternatives warrant running the feedback process because they can affect regional travel patterns. Less significant improvements may not result in a significant change in trip distribution patterns.

For any and all interim milestone and horizon years, speed feedback should be executed to closure for the base network in each of these years. This base network could be defined as a no-build, existing plus committed, or build network for each of these future years. In any given year, speed feedback should generally be run when a scenario includes major changes to socioeconomic data assumptions or significant changes to the roadway network.

When comparing minor improvements, it is often best to run the model with speed feedback disabled. This will increase consistency between scenarios being compared.

Transit Assignment

Transit person trips resulting from the mode choice model are assigned to the transit route system. Each trip is assigned from zone centroid to zone centroid using walk or drive access links, transit routes, and walk egress links. The transit assignment step does not include capacity constraint, so increasing transit volumes do not result in diversion of transit trips to other transit service.

Transit assignment results include the total number of boardings at each transit stop, as well as transit volumes on all stop to stop transit route segments. However, transit results are generally best evaluated at the systemwide or route group level. Individual route, stop, and segment values have not been validated to observed conditions. Prior to using the model to support detailed transit corridor studies, a focused transit model calibration and validation effort is recommended.

Assignment Validation

Roadway volumes resulting from traffic assignment were compared against traffic count data. This process, called traffic assignment validation, ensures that the model is reasonably representing observed traffic patterns. Traffic counts were obtained from various sources and placed on the roadway network. Travel model results were then compared to traffic count data using a variety of techniques, including regional comparisons, screenline comparisons, and visual inspection of individual link data. Further discussion of the validation is included in the Technical Documentation.

Overall vehicle trip activity was validated by comparing count data to model results on all links where count data is available using two statistics: Model Volume as compared to Count Volume and Model VMT as compared to Count VMT. These statistics were reviewed at the facility type, area type, and regional level and are shown in Table 5.4.

Category	Number of Counts	Model Volume / Count Volume	Model VMT / Count VMT	Target
Freeway	110	95.9%	96.8%	+/- 10%
Expressway	28	105.1%	105.5%	+/- 10%
Tollway	10	108.0%	114.8%	+/- 10%
Principal Arterial	357	98.5%	97.5%	+/- 10%
Minor Arterial	515	105.7%	103.2%	+/- 15%
Collector	550	98.7%	102.7%	+/- 25%
CBD	103	107.2%	99.8%	n/a
Urban	409	93.4%	94.2%	n/a
Suburban	565	102.8%	102.1%	n/a
Rural	528	117.3%	113.5%	n/a

Table 5.4 Regional Assignment Validation

Note: Targets are a set of general guidelines shown for reference and are not a rule or regulation.

Sensitivity Tests

The base year validation measures described above and in the Technical Documentation are critical in ensuring the validity of the model. These measures show that the model adequately reproduces observed trip generation, distribution, mode split, and assignment patterns. However, the base year validation measures are *static* – they do not demonstrate the sensitivity of the model. The WAMPO Model was run through a series of simple sensitivity tests to demonstrate that it provides appropriate sensitivity to variables that are important in the forecasting and planning process. These tests included:

- Socioeconomic Data Adjustments – both small scale and large scale changes were examined for reasonableness; and,

- Network Adjustments – critical links in both rural and urban areas were removed from the roadway network to ensure the WAMPO Model reflected the expected diversion of traffic and congestion.

Additional details and accompanying results for these sensitivity tests are included in the Technical Documentation.