SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC

Topic Area	TRAVEL/4	Bill Allen's Simplified Tour Based Model	MWCOG	UMD mesoscopic model	DTA Lite	Agent Based Model	Comments
Land Use & SE Inputs							
LU Types	MWCOG Round 8.2 is the currently adopted land activity forecast that is input to the Travel 4 model. CTPP based employment adjustment is done to ensure a consistent employment definition is used by all counties and jurisdictions in the modeled area. Land use types include Households, Household population, group quarters population, retail employment, industrial employment, office employment, and other employment (Ref 2, page 21)	The specific land uses vary by modeled region but typically include, HH, school enrollment, and employment (Ref 8, slide 16)	Round 8.2 is the currently adopted land activity forecast that is input to the regional travel model. CTPP based employment adjustment is done to ensure a consistent employment definition is used by all counties and jurisdictions in the modeled area. Land use types include Households, Household population, group quarters population, retail employment, industrial employment, office employment, and other employment(Ref 2, page 21)	Land use is not an input	Land use is not an input	Land use is not an input	Bill Allen Tour Based Model developed for Atlanta Regional Commission (ARC), Charlotte MPO, and Brunswick, GA. ARC and Charlotte documentation listed to supplement Bill Allen documentation as the same survey data and networks were used in the estimation of the tour based models
Base Year Inventory	2010 Census (households and population), 2010 American Community Survey ACS (share of households by size and vehicles available), 2010/2011 TPB Geographically-Focused Household Travel Survey (HTS) (share daily trips made by mode), 2010 HPMS Reports (vehicle miles of travel), 2010 HPMS traffic counts (daily link volumes), 2010 Metrorail faregate counts (station boardings) Base year 2010, design year 2040 (Ref 2, page 40)	Varies depending on model development location. Tour based models have been developed for Brunswick, GA (2010), Atlanta, GA (2014) and Charlotte, NC (2015). A survey of truck travel was conducted in 1996 and that was used to develop existing truck model (Ref 10, page 156) ARC conducted a regional transit on-board survey in 2009-2010 (Ref 10, page 129) Base year 2015, design year 2040	2010 Census (households and population), 2010 American Community Survey ACS (share of households by size and vehicles available), 2010/2011 TPB Geographically-Focused Household Travel Survey (HTS) (share daily trips made by mode), 2010 HPMS Reports (vehicle miles of travel), 2010 HPMS traffic counts (daily link volumes), 2010 Metrorail faregate counts (station boardings) Base year 2010, design year 2040(Ref 2, page 40)	Land Use is not an input to these models	Land Use is not an input to these models	Land Use is not an input to these models	
TAZs							

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Average Size	3812 Traffic Analysis zones in the region, with 466 in Montgomery County. More TAZ detail within Montgomery County detail within Montgomery County Given the coarseness of the household travel survey data, the results of the validation were aggregated into districts and super districts. There are 12 districts defined for the county, there are as follows: Bethesda, Silver Spring, Potomac, North Bethesda, Wheaton, White Oak, Rockville, Aspen Hill, Clarksburg, Poolesville, Olney, and Cloverly. The districts were grouped into super districts based on the socio-economic characteristics, and development pattern. The denser areas of the County were grouped into the inner super district, the more traditional suburban development areas were grouped into the middle super district, and the outer less developed areas were grouped into the outer super district. (Ref 5, P 10, 11) Aggregated Super Districts.	2000+ TAZ s in ARC travel demand model (Ref 12, page 21) 1,816 TAZs in Charlotte model (Ref 11, page 10-6)	3722 Traffic Analysis zones in the region, with 376 in Montgomery County (Ref 3, page 4)	Zone structure from travel demand models typically used with additional TAZ refinement in focus areas(Ref 9, page 12)	Zone structure from travel demand models typically used with additional TAZ refinement in focus areas(Ref 7, page 6)	Zone structure from travel demand models typically used with additional TAZ refinement in focus areas(Ref 9, page 12)	Specific TAZ size varies depending on area type and density
Data Collection							

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC

Topic Area	TRAVEL/4	Bill Allen's Simplified Tour Based Model	MWCOG	UMD mesoscopic model	DTA Lite	Agent Based Model	Comments
Traffic Counts	Daily classification traffic counts were used for validation purposes based on summary table comparisons of observed vs modeled (Ref 5, page 33)	2000 year daily classification traffic counts were used for validation purposes based on summary table comparisons of observed vs modeled (Ref 10, page 21)	Daily classification traffic counts used in validation were taken directly from TPB's Regional Transportation Data Clearinghouse (6400 directional traffic counts for the year 2010) (Ref 1, page 4)	Peak period traffic counts are needed in 15 minute intervals for matrix re-estimation and time slicing of trip OD tables(Ref 9, page 12)	Peak period traffic counts are needed in 15 minute intervals for matrix re-estimation and time slicing of trip OD tables. (Ref 7, page 26)	Peak period traffic counts are needed in 15 minute intervals for matrix re-estimation and time slicing of trip OD tables(Ref 9, page 12)	MSHA maintains a statewide database of classified intersection turning movement counts stratified into 15 minute intervals for current and historical years. These counts were used in the matrix re-estimation process
Transit Ridership	Transit ridership is summarized for Heavy Rail, Commuter Rail, Commuter Bus, and local bus by line and stop. (Ref 3, P 19,20)	To improve model's representation of the geographic nature of transit travel and better represent the split between rail and bus travel, a pedestrian environment factor was introduced to differentiate between suburban and urban locations that for the most part mimicked the implied rail preferences without explicitly favoring any one mode over another. This approach also helps to reflect the fact that transit ridership is higher in urban settings than it is in less dense environments. ((Ref 10, P 132) ARC conducted a regional transit on-board survey in 2009-2010 (Ref 10, page 129)	Transit ridership is summarized for Heavy Rail, Commuter Rail, Commuter Bus, and local bus by line and stop. Ref 3, P 19,20)	N/A model only used for highway assignment	N/A model only used for highway assignment	N/A model only used for highway assignment	
Travel Time Survey	N/A	Varies depending on modeled region	N/A	Not conducted	Not conducted	Not conducted	
Transit Survey	Several on-board transit surveys data from 2007 or 2008, and 2008 Regional Bus Survey(Ref 1, page 2)	ARC had an on-board transit survey conducted in late 2000 and early 2002 which was used in developing travel demand models (Ref 10, page 129)	Several on-board transit surveys data from 2007 or 2008, and 2008 Regional Bus Survey(Ref 1, page 2)	N/A model only used for highway assignment	N/A model only used for highway assignment	N/A model only used for highway assignment	
External Survey	Auto External Survey completed in 1994. Truck External Survey completed 1996 (Ref http://www.mwcog.org/transportation/activities/models/data.asp	Initial external and truck models were developed for ARC based on a survey conducted by ARC in 1994-1995 at 30 sites on the periphery of the 13-county travel model study area. The roads were selected so that the survey sites captured nearly all of the high volume facilities where traffic enters and exits the region. (Ref 10, page 147)	Auto External Survey completed in 1994. Truck External Survey completed 1996 (Ref http://www.mwcog.org/transportation/activities/models/data.asp)	External data from travel demand model trip tables used in assignment therefore no External Surveys are required (Ref 9, page 12)	External data from travel demand model trip tables used in assignment therefore no External Surveys are required (Ref 7, page 6)	External data from travel demand model trip tables used in assignment therefore no External Surveys are required (Ref 9, page 12)	
Networks							

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Highway Link Attributes	Distance, Jurisdiction Code, Screenline code, Link Facility Type code, Toll value, Toll Group code (No of lanes, limit code), Geometry network link identifier, Logical network link identifier, Planning year of network, project identifier, TAZ, Area type, Speed class, Capacity class, factor for deflating current year tolls to constant year tolls, toll value in current year dollars, toll value in current year dollars- variably priced tolled facilities only, highway time based on initial look up speeds. (Ref 2, page 112, 113	Highway Link Attributes are: Beginning Node, Ending node, Link distance, Link Restriction Parameters (0=No restriction, 1=Trucks prohibited, 2=HOV lanes, 3=Managed lanes, 4=Truck only lanes, 5=Truck prohibition), Number of through lanes in one direction, Number of auxiliary lanes. Additional link attributes added are Link area type (CBD, High density urban, Medium density urban, Low density urban, Exurban, Rural), Total link capacity, Fixed Toll Cost, Free flow speed, Bus Speed, Bus Time. (Ref 10, page 250)	Distance, Jurisdiction Code, Screenline code, Link Facility Type code, Toll value, Toll Group code (No of lanes, limit code), Geometry network link identifier, Logical network link identifier, Planning year of network, project identifier, TAZ, Area type, Speed class, Capacity class, factor for deflating current year tolls to constant year tolls, toll value in current year dollars, toll value in current year dollars- variably priced tolled facilities only, highway time based on initial look up speeds. (Ref 2, page 112, 113	Link attributes vary with application. Links are input directly from planning models and retain those attributes including functional class, road type, capacity, speed, and lanes. (Ref 2, page 112)	Link Type, Link Type name, Type Code (f=freeway, h=highway/expressway, a=arterial, c=connector, r = ramp), lane capacity, speed limit, number of lanes. (Ref 7, P 21 and 22)	Link attributes vary with application Links are input directly from planning models and retain those attributes including functional class, road type, capacity, speed, and lanes. (Ref 2, page 112)	
Highway Node Attributes	X, Y coordinates in highway network (Ref 2, page 112)	Varies depending on modeled region	X, Ycoordinates in highway network (Ref 2, page 112)	Node attributes vary with application **Control Data:** Signal timing and phasing data are critically needed for typical DTA analysis; obtaining signal timing data was a challenge for ICC sub-model development (Ref 9, page 15)	The node layer can use arbitrary coordinate system, but a WGS 84 (long/lat) coordinate system is preferred to export data to Google Earth/Google Map. (Ref 7, P 7) **Control Data:** Signal timing and phasing data are critically needed for typical DTA analysis (Ref 7, P 6)	Node attributes vary with application **Control Data:** Signal timing and phasing data are critically needed for typical DTA analysis (Ref 9, page 15)	
Transit Attributes	Time, Mode, user designated color, Stop node A, stop node B, Distance, Name of line on this link, service frequency, Additional attributes included due to transit assignment: link sequence, line owner, volume, number of trip boardings at A, number of exits at A, number of boardings at B, number of exits at B (Ref 2, page 210)	A transit network contains lines and support links. Lines are user defined transit routes. Support links provide connectivity between transit lines and between zone centroids and transit lines. Typical support link types are walk, park and ride, and transfer links. Transit assignments use daily trips that are separated by mode of access (walk to premium, walk to local, and drive to transit) and general purpose (work-non-work). (Ref 10, page 254)	Time, Mode, user designated color, Stop node A, stop node B, Distance, Name of line on this link, service frequency, Additional attributes included due to transit assignment: link sequence, line owner, volume, number of trip boardings at A, number of exits at A, number of boardings at B, number of exits at B (Ref 2, page 210)	N/A only used for highway assignment	N/A only used for highway assignment	N/A only used for highway assignment	

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Non-motorized	Model included the development of non-motorized trips for all (work-non-work) purposes. However, non-motorized travel will be developed at the trip generation stage only. (Ref 4, page 1-8)	It is possible to estimate the proportion of non-motorized trips using information on the wealth of the traveler, the urban form in terms of density, and the availability of opportunities in terms of the number of jobs and people within a reasonable distance. While the number of non-motorized trips was very small, it was possible to develop a statistically significant model by using disaggregate modelling procedures. That is logit calibration and estimating proportions rather than trips. (Ref 10, page 32)	Model included the development of non-motorized trips for all (work-non-work) purposes. However, non-motorized travel will be developed at the trip generation stage only. (Ref 4, page 1-8)	N/A only used for highway assignment	N/A only used for highway assignment	N/A only used for highway assignment	
Model vs. actual detail	More local collectors and streets are included in Montgomery County. 300 miles of highway links added to the network. The majority of new links were coded as minor collectors/local roadways. (Ref 5, page 4)	Facility type is a required link attribute. Atlanta Highway networks include speed limit, Median Type, Shoulder, Access, Strategic attributes. Other recommended attributes are Countstation, Dircount, Screenline, Fclass. (Ref 10, page 249)	Model does not include local streets and very few local collectors. (See comments for reference)	Model includes traffic signal information and turning lane information at nodes. Travel demand model networks are typically exported and retain link and node geometries and scale. (Ref 9, page 15)	**Network Data:** The network topology is widely coded in GIS format Model includes traffic signal information and turning lane information at nodes. Travel demand model networks are typically exported and retain link and node geometries and scale. (Ref 7, page 6)	Model includes traffic signal information and turning lane information at nodes. Travel demand model networks are typically exported and retain link and node geometries and scale. (Ref 9, page 15)	A review of the MWCOG model indicated that many of the local streets were not coded throughout the region
Vehicle Availability							
Categories	The demographic models are used to disaggregate the total number of zonal households across 64 cross-classes: 4 household income groups by 4 household size groups (1, 2, 3, 4+ persons) by 4 vehicle availability groups (0, 1, 2, and 3+ vehicle available). (Ref 4, page 1-8)	Socio-economic independent variables are: HH size (1,2,3,4+), HH Income (under $20K, 20-50K, 50-100K, over 100K+) Number of workers (0,1,2,3+) Number of children (0,1,2,3+) Number of autos (0,1,2,3+) (Ref 10, page 7)	The demographic models are used to disaggregate the total number of zonal households across 64 cross-classes: 4 household income groups by 4 household size groups (1, 2, 3, 4+ persons) by 4 vehicle availability groups (0, 1, 2, and 3+ vehicle available). (Ref 4, page 1-8)	N/A	N/A	N/A	

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Method	The allocation of households to each cross-class is made at the traffic analysis zone level. Peak hour transit accessibility measures are used as part of the demographic (vehicle Availability) submodel step. (Ref 4, page 1-8)	The automobile ownership model is a logit model which estimates the probability of a household owning 0, 1, 2, 3, or more automobiles. The logit model is implemented by calculating a disutility expression for each of the automobile ownership choices. (Ref 10, page 44)	The allocation of households to each cross-class is made at the traffic analysis zone level. Peak hour transit accessibility measures are used as part of the demographic (vehicle Availability) submodel step. (Ref 4, page 1-8)	N/A	N/A	N/A	
Variables	Disaggregate choice model used. Input variables include household size, household income, area type, and transit accessibility (Ref 4, page 3-8)	The automobile ownership equations have three independent variables. Income, density of area, and automobile importance (Ref 10, page 44)	Disaggregate choice model used. Input variables include household size, household income, area type, and transit accessibility (Ref 4, page 3-8)	N/A	N/A	N/A	
Calibration	Utility coefficients adjusted to calibrate to observed conditions. Estimated/observed difference < 1% (Ref 4, page 3-9)	For calibration, each household in the survey data set has a value for each of the five socio-economic variables. In the application of model for a future year, the ARC land use model estimates households by household size, and income group. (Ref 10, page 7) Model results were compared to census data for validation purposes. At the regional level model results were compared to CTPP households cross tabulated by number of autos. and income group. (Ref 10, page 49, 50) Absolute differences seem well within accepted ranges. The auto ownership model was further validated by comparing model results to census data at census tract level.	Utility coefficients adjusted to calibrate to observed conditions. Estimated/observed difference < 1% (Ref 4, page 3-9)	N/A	N/A	N/A	
Trip Generation							

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC

Topic Area	TRAVEL/4	Bill Allen's Simplified Tour Based Model	MWCOG	UMD mesoscopic model	DTA Lite	Agent Based Model	Comments
Method	Trip generation involves the application of daily trip rates to the number of households, in each of the 64 classes, and to the number of jobs. Trip attractions are computed by purpose as function of zonal land use attributes. External productions and attractions are entered as an exogenous input, by purpose, into the trip generation process. External travel relates to auto person, commercial vehicle and truck travel only (transit externals are not considered in the model). The home based productions and attractions are developed by the four income levels. (Ref 4, page 1-10) Productions in Montgomery County are redistributed by purpose and income to better match observed data in county (Ref 4, page 5)	Tours are estimated at the household level instead of trips. Tours are round trip and include intermediate stops and an "anchor end" which is typically work or school. Tours for each household are estimated using logit model and Monte Carlo simulation. (Ref 8, slide 26)	Trip generation involves the application of daily trip rates to the number of households, in each of the 64 classes, and to the number of jobs. Trip attractions are computed by purpose as function of zonal land use attributes. External productions and attractions are entered as an exogenous input, by purpose, into the trip generation process. External travel relates to auto person, commercial vehicle and truck travel only (transit externals are not considered in the model). The home based productions and attractions are developed by the four income levels. (Ref 4, page 1-10)	N/A	N/A	N/A	
Input Variables	House hold income quartiles: less than $50,000, $50,000-$99,999, $100,000-149,999, and $150,000 or more. (Ref 4, page 3-2)	HH size (1,2,3,4+), HH Income (under $20K, 20-50K, 50-100K, over 100K+) Number of workers (0,1,2,3+) Number of children (0,1,2,3+) Number of autos (0,1,2,3+) (Ref 10, page 7)	House hold income quartiles: less than $50,000, $50,000-$99,999, $100,000-149,999, and $150,000 or more (Ref 4, page 3-2)	N/A	N/A	N/A	
Rates	Trip rates reflect both motorized (transit, and automobile) and non-motorized (bicycle, and walk) person travel. (Ref 4, page 1-10)	No rates are used; the HH synthesis logit model and Monte Carlo simulation replace this (Ref 8, slides 17-23)	Trip rates reflect both motorized (transit, and automobile) and non-motorized (bicycle, and walk) person travel. (Ref 4, page 1-10)	N/A	N/A	N/A	

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Purposes	Home-Based Work (HBW), Home-Based Shop (HBS), Home-Based Other (HBO), Non-Home-Based Work (NHW), Non-Home-Based Other (NHO) Commercial vehicle purpose (consisting of both autos and light duty trucks), and two truck types, medium and heavy, are also modeled. Medium size: 6+ tires, 2 axles, single unit), large size trucks: all combination trucks (Ref 4, page 4-1)	Varies depending on modeled region, typically HBW, HBS, HBSchool, HB University, HB Other, and Non-Home Based. (Ref 10, page 6)	Home-Based Work (HBW), Home-Based Shop (HBS), Home-Based Other (HBO), Non-Home-Based Work (NHW), Non-Home-Based Other (NHO) Commercial vehicle purpose (consisting of both autos and light duty trucks), and two truck types, medium and heavy, are also modeled. Medium size: 6+ tires, 2 axles, single unit), large size trucks: all combination trucks (Ref 4, page 4-1)	N/A	N/A	N/A	
Special Generators	No special generators documented	No special generators documented	No special generators documented	Can be approximated by factoring specific OD interchanges in trip table	Can be approximated by factoring specific OD interchanges in trip table	Can be approximated by factoring specific OD interchanges in trip table	Factoring specific OD interchanges has been conducted by Vision on previous projects successfully including the Howard County model development
Balancing	Attractions are balanced to the production ends (Ref 5, page 11)	Round trip tours eliminate the need to balance trips; no partial trips as in trip based models (Ref 8, slide 7)	Attractions are balanced to the production ends (Ref 5, page 11)	N/A	N/A	N/A	
Sensitivity to local factors	More zonal detail in Montgomery County improves modeling of mixed use and TOD development (Ref 5, page 4)	More reflective of actual HH trip generation; better captures mixing of land uses and transit options than trip based models (Ref 8, slide 55)	Model estimated at regional level; therefore does not focus on Montgomery County local factors (Ref 4, page 1-2)	N/A	N/A	N/A	
Trip Distribution							

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Method	Uses standard gravity model for formulations and makes use of a composite time function that represents a blending of transit and highway travel times. The gravity model is doubly constrained for all five trip purposes. The distribution step involves separate gravity model runs for 30 travel markets. (Ref 4, page 1-10) Bridge penalties are implemented as link attributes. Non-work, non-motorized trip rates (productions and attractions) are increased by 30 percent. Scaling is done after motorized and non-motorized trips are added together. (Ref 2, p 14) Internal to external (IX) extraction has been removed.	Destination choice model used. Tours consider zones within a distance parameter that is set in the model depending on the modeled region (Ref 8, slide 33)	Uses standard gravity model for formulations and makes use of a composite time function that represents a blending of transit and highway travel times. The gravity model is doubly constrained for all five trip purposes. The distribution step involves separate gravity model runs for 30 travel markets. (Ref 4, page 1-10) Bridge penalties are implemented as link attributes. Non-work, non-motorized trip rates (productions and attractions) are increased by 30 percent. Scaling is done after motorized and non-motorized trips are added together. (Ref 2, p 14) Internal to external (IX) extraction has been removed.	N/A	N/A	N/A	
Parameters	Composite time which includes congested highway time, metrorail time and toll cost(Ref 4, page 5-3)	Travel Time, area type, CBD dummy, intra-county dummy, accessibility, jobs, population, school enrollment (Ref 8, slide 49)	Composite time which includes congested highway time, metrorail time and toll cost (Ref 4, page 5-3)	N/A	N/A	N/A	
Friction/K Factors	Trial and error used in developing Friction factors. Gamma function used to develop friction factor curves (Ref 4, P 5-6, 5-7)	Using 2001-2002 survey trip tables, and the composite travel time files a standard gravity model calibration process was conducted. This process involved adjusting the gravity model friction factors until the computed average trip length of model was within 3 percent of the average trip length observed in the survey data. (Ref 10, page 65)	Trial and error used in developing Friction factors. Gamma function used to develop friction factor curves (Ref 4, P 5-6, 5-7)	N/A	N/A	N/A	
External Traffic	Modelled separately by purpose and facility type (interstate vs non-interstate) (Ref 4, P 2-3, 2-4,2-5)	Separate sub-model included to estimate I/I and I/X trips. X/X trip modeling varies by modeled region (Ref 8, slide 49)	Modelled separately by purpose and facility type (interstate vs non-interstate) (Ref 4, P 2-3, 2-4,2-5)	N/A	N/A	N/A	
Convergence	Relative gap of 10^3 (0.001) or 300 user equilibrium iterations (Ref 4, page 8-2)	ARC model uses Relative gap of (0.001). (Ref 14, Slide 16)	Relative gap of 10^3 (0.001) or 300 user equilibrium iterations (Ref 4, page 8-2)	N/A	N/A	N/A	

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Calibration and validation	The objective was to achieve 90 percent of the trip interchanges within+-20 percent of the observed travel time data for work trips and +-25 percent for non-work trips when compared to Household Survey Data which was achieved. (Ref 3, page 14)	Average tour within 7% of observed data (Ref 8, slide 35)	Observed/Modeled trip lengths are used for validation. No validation criteria listed (Ref 4, page 5-10)	N/A	N/A	N/A	
Modal Choice							
Method	Nested logit mode choice model (NLMC) is used. (Ref 2 - Page 161) Production areas: DC core/urban, MD urban, VA Core/urban, MD suburban, VA suburban (Ref 2 - Page 172) Attraction areas: DC core, VA core, Urban, Suburban (Ref 2 - Page 172) Percent walk-to-transit (PWT) values used by the mode choice model - two distance thresholds are used. Short walk to transit <=0.5 mile, and long walk to transit >0.5 mile and <=1 mile. (Ref 2 - Page 178)	Model estimates mode for each tour using logit model (Ref 8, slide 46)	Nested logit mode choice model (NLMC) is used. (Ref 2 - Page 161) Production areas: DC core/urban, MD urban, VA Core/urban, MD suburban, VA suburban (Ref 2 - Page 172) Attraction areas: DC core, VA core, Urban, Suburban (Ref 2 - Page 172) Percent walk-to-transit (PWT) values used by the mode choice model - two distance thresholds are used. Short walk to transit <=0.5 mile, and long walk to transit >0.5 mile and <=1 mile. (Ref 2 - Page 178)	N/A	N/A	N/A	
Parameters	The nested logit mode choice model uses three types of market segments: Household income, geography, and access to transit. Household income quartiles: less than $50,000, $50,000-$99,999, $100,000-149,999, and $150,000 or more Geography: DC core, VA core, DC urban, MD urban, VA urban, MD suburban, VA suburban. (Ref 2 - Page 169)	Summarized by purpose, socioeconomic class, mode of access, presence of transfer, and transfer sub-mode. (Ref 10, page 129)	The nested logit mode choice model uses three types of market segments: Household income, geography, and access to transit. Household income quartiles: less than $50,000, $50,000-$99,999, $100,000-149,999, and $150,000 or more Geography: DC core, VA core, DC urban, MD urban, VA urban, MD suburban, VA suburban. (Ref 2 - Page 169)	N/A	N/A	N/A	

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Modes	Consists of five modes corresponding to HBW, HBS, HBO, NHW, NHO purposes. The models are used to apportion total motorized trips by travel mode. Nested-logit mode choice model with 15 travel modes Although the nesting structure does not include explicit branches for specialized transit modes - such as light-rail transit (LRT), bus rapid transit (BRT), and streetcar - the model is designed to deal with these special transit modes (Ref 4, P 1-10)	The ARC mode choice models use an underlying nested logit structure to predict the probability individuals in the Atlanta metropolitan area will select one of the several different modes of transportation (Ref 10, page 129)	Consists of five modes corresponding to HBW, HBS, HBO, NHW, NHO purposes. The models are used to apportion total motorized trips by travel mode. Nested-logit mode choice model with 15 travel modes Although the nesting structure does not include explicit branches for specialized transit modes - such as light-rail transit (LRT), bus rapid transit (BRT), and streetcar - the model is designed to deal with these special transit modes (Ref 4, P 1-10)	Only SOV, HOV, and truck modes	Only SOV, HOV, and truck modes	Only SOV, HOV, and truck modes	
Calibration and validation	The validation goal was to be within +-10% of the transit mode share for HBW trips and +- 20% for non-HBW trips. The focus was on the transit mode shares as there are very limited HOV facilities in the County. The validation effort was focused at the district level for the mode choice model. The mode choice calibration met this target. (Ref 3, page 20)	Calibration of the mode choice models entails adjusting the bias coefficients until the estimated modal shares match the target shares by purpose, strata, and sub-mode. This was done using the self-calibration subroutine within the mode choice model.	Transit survey used for calibration and validation. Modeled results within 5% of observed results for all trip purposes Ref 3, page 6-28)	N/A	N/A	N/A	
Trip Assignment							

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC							
Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Highway method and parameters	The assignment process is a multi-class UE assignment. (Ref 2 - page 199) Highway link volumes are developed for SOVs, HOV-2, HOV+3, commercial vehicles, trucks, and airport passenger vehicles by time period. A method of successive averages (MSA) is applied to daily link volumes to ensure that regional speeds and VMT close in on an equilibrium condition. Four time of day periods used for assignment. (Ref 2 - page 26) Highway assignment is done with trip tables in origin/destination formats. It is capacity constrained. Highway assignment is done in each of the five speed feedback loops (pump prime, i1, i2, i3, and i4) (Ref 2 - page 207)	Conventional UE assignment is used. Volume/Delay function adjusted using real speed data for ARC model as illustrated in Figures 8.2-8.5 in ARC model documentation (Ref 8, slide 51) (Ref 10, P 236-238)	The assignment process is a multi-class UE assignment. (Ref 2 - page 199) Highway link volumes are developed for SOVs, HOV-2, HOV+3, commercial vehicles, trucks, and airport passenger vehicles by time period. A method of successive averages (MSA) is applied to daily link volumes to ensure that regional speeds and VMT close in on an equilibrium condition. Four time of day periods used for assignment. (Ref 2 - page 26) Highway assignment is done with trip tables in origin/destination formats. It is capacity constrained. Highway assignment is done in each of the five speed feedback loops (pump prime, i1, i2, i3, and i4) (Ref 2 - page 207)	Trip-based, simulation-based, link level dynamic traffic assignment framework using origin-destination matrices with fixed departure times. Level of Service is calculated at the link level. Time dependent user equilibrium with realistic, but simplified vehicle simulation. DTALite uses a light-weight dynamic network loading simulator that embeds Newell's simplified kinematic wave model and a mesoscopic agent-based DTA procedure to incorporate driver's heterogeneity; (Ref 9, page 17-19)	**Demand Data:** Trip tables at a TAZ level can be imported from regional traffic planning models for different peak and off peak periods. DTALite is an open-source dynamic traffic assignment model. DTALite uses a computationally simple but theoretically rigorous traffic queuing model in its lightweight mesoscopic simulation engine. To reduce data preparation efforts, it only requires a minimal set of static traffic assignment data and some time-dependent OD demand pattern estimates. DTALite adopts a trip-based, simulation-based dynamic traffic assignment framework using origin-destination matrices with fixed departure times. Time dependent user equilibrium with realistic, but simplified vehicle simulation.	Trip-based, simulation-based link level dynamic traffic assignment framework using origin-destination matrices with fixed departure times. Level of Service is calculated at the link level. Time dependent user equilibrium with realistic, but simplified vehicle simulation. (Ref 9, page 17-19)	Agent based model is actually used in combination with UMD mesoscopic model and DTA Lite model (DTA models in general); therefore the same values are used for these cell descriptions for the remainder of the table (Ref 9, page 17-19)
Transit method and parameters	Transit trips are commonly assigned to the shortest available transit path. Transit trip tables are converted from Production/Attraction (P/A) format to Origin/Destination (O/D) format prior to assignment on combined highway/transit network. In-vehicle time (ivt), Auto access time (aat), walk access time (ovtwa), and other out-of-vehicle time (ovtot) are used. The best path is calculated from multiple choices based on Utility. (Ref 3, P 25)	Transit assignment use daily trips that are separated by mode of access (walk to premium, walk to local, and drive to transit) and general purpose (work and non-work) (Ref 10, page 229) The Metrolina model uses a transit assignment method created by Caliper called "Path Finder" Path Finder calculated transit trip paths including transfer time, distance, wait time, and cost. (Ref 13, page 134)	Transit assignment is done with trip tables in production/attractions (P/A) format. Transit assignment is conducted at the conclusion of the i4 speed feedback loop. In-vehicle time (ivt), Auto access time (aat), walk access time (ovtwa), and other out-of-vehicle time (ovtot) are used. The best path is calculated from multiple choices based on Utility (Ref 2 - Page 207)	No transit assignment	No transit assignment	No transit assignment	

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Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Capacity/speed/volume-delay	Conical volume delay function. Parameters include free flow speed, capacity per lane, conical function parameters (Ref 4, page 8-12)	Ratios of assigned traffic volume versus the capacity are used to predict how travel times (and hence, delays) increase as roadway volumes build up to and beyond the capacity of the roadway. Revised volume-delay functions were internally developed using the results of empirical studies on roadway volume and delay distributions in urban area over a 24 hour period (Ref 10, page 233)	Conical volume delay function. Parameters include free flow speed, capacity per lane, conical function parameters (Ref 4, page 8-12)	Conical volume delay function. Parameters include free flow speed, capacity per lane, conical function parameters (Ref 9, page 20)	Conical volume delay function. Parameters include free flow speed, capacity per lane, conical function parameters (Ref 7, page 66)	Conical volume delay function. Parameters include free flow speed, capacity per lane, conical function parameters (Ref 9, page 20)	
Convergence	Progressive relative gap stopping criteria is used. The value of UE relative gap threshold changes as the model progresses. Relative gap<=10^{-2}, for pp-i2′ <=10^{-3}, for i3, <=10^{-4} for i4 and UE iterations 1000. Rum time is approximately 30 hours (Ref 2 - Page 64)	Varies depending on modeled region (2-8 hours for small to medium sized region) (Ref 8, slide 52) The Metrolina model allows up to 250 iterations to ensure each assignment reaches the set convergence of 0.01. The assignment is repeated four times – once for each time period (AM peak period, PM peak period, midday, and night). (Ref 13, page 102)	Progressive relative gap stopping criteria is used. The value of UE relative gap threshold changes as the model progresses. Relative gap<=10^{-2}, for pp-i2′ <=10^{-3}, for i3, <=10^{-4} for i4 and UE iterations 1000. Run time is approximately 30 hours (Ref 2 - Page 64)	Not documented, but cited as a challenge	Not documented, but cited as a challenge	Not documented, but cited as a challenge	

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Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Calibration and validation	Travel/4 validation is focused on daily traffic volumes in Montgomery County. The screenline results indicate observed/estimated % differences ranging from 1%-15%. Transit assignment screenline results indicate observed/estimate % difference of 5% or less. Adjustments to centroid locations and zone refinement were the primary basis for model calibration. The highway and transit assignments meet the validation criteria. (Ref 3, P 26)	The main data source for the calibration of travel demand models was a household travel survey of 8,000 households conducted for ARC from 2001-2002. In addition ARC had an on-board transit survey conducted in late 2000 and early 2002 which was used in developing travel demand models and a survey of air passengers at Hartsfield International Airport in 2001. Extensive speed studies were conducted to assist with the development of network speeds. Over 5,000 daily traffic counts were utilized to perform the highway assignment validation. Vehicle classification counts were also collected to develop a new commercial vehicle and truck model. (Ref 10, page 4)	Primary performance issues identified and addressed during calibration: VMT over estimated in District of Columbia, the City of Alexandria, and Loudoun County. Traffic crossings over Potomac River were overestimated. Radial highway screenline crossings within DC were over estimated. (Ref 1, P 16) The final results indicate the estimated to observed VMT in the District of Columbia is 0.98, in the City of Alexandria is 1.14, and at MSA level is 1.00. VMT performance of the modeled region is 1.00. Adjustments to volume-delay functions used for model calibration. Daily transit assignments capability is yet to be fully calibrated and validated	Modeled vs observed volumes within 7% after model calibration (Ref 9, page 23)	Model calibration and validation efforts ongoing	Modeled vs observed volumes within 7% after model calibration (Ref 9, page 23)	
Pricing							
Consideration	Composite time introduced to model impacts of tolling on destination choice. Includes toll per mile capability. Double run feature added where HOV trips are first assigned to HOT lanes in Northern Virginia to obtain HOV skim times on the HOT lanes prior to a final assignment which uses the HOV skim times from base run as skim input instead of free flow travel time.	Opportunities for improved toll modeling cited in documentation (Ref 8, slide 51)	Composite time introduced to model impacts of tolling on destination choice. Includes toll per mile capability. Double run feature added where HOV trips are first assigned to HOT lanes in Northern Virginia to obtain HOV skim times on the HOT lanes prior to a final assignment which uses the HOV skim times from base run as skim input instead of free flow travel time.	Road pricing strategies are where the dollar values are converted to generalized travel time through a typical value of time coefficients. One value of time used (Ref 9, page 36)	Road pricing strategies are where the dollar values are converted to generalized travel time through a typical value of time coefficients (e.g. $10 per hour). Pricing type id are: 1: single occupancy vehicle, 2: high occupancy vehicle, 3: truck, 4: intermodal travelers using transit. Pricing type, and value of time shown below: pricing_type / default_VOT 1 / 10 2 / 20 3 / 30 4 / 10 (Ref 7, P 22)	Road pricing strategies are where the dollar values are converted to generalized travel time through a typical value of time coefficients. One value of time used (Ref 9, page 36)	

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Topic Area	**TRAVEL/4**	**Bill Allen's Simplified Tour Based Model**	**MWCOG**	**UMD mesoscopic model**	**DTA Lite**	**Agent Based Model**	**Comments**
Auto Operating Cost	Relates to out-of-pocket expenditure associated with the requirements of automobile trip including fuel, oil, maintenance, tire wear etc. currently using 10 cents per mile and this rate is not varied over time (Ref 2, P 196	Average travel cost per person trip per mode by purpose using 2005 Federal mileage rate adjusted to 2000 year dollars – 0.326 (Ref 12, page 123)	Relates to out-of-pocket expenditure associated with the requirements of automobile trip including fuel, oil, maintenance, tire wear etc. currently using 10 cents per mile and this rate is not varied over time (Ref 2, P 196	Not documented	Not documented	Not documented	
Parking Cost	A flat rate based on the prevalent metered rates was used for each area type. For area type 1, the most prevalent rate of parking value of $2.00, for area type 2 $1.00, and for area type 3 the value of $0.25 per hour was used. For area type 4 and higher no parking cost was anticipated.	Parking cost model was revised to consider minimum density of employees per acre. A parking cost over ride feature also included in the program. (Ref 12,page 16)	A flat rate based on the prevalent metered rates was used for each area type. For area type 1, the most prevalent rate of parking value of $2.00, for area type 2 $1.00, and for area type 3 the value of $0.25 per hour was used. For area type 4 and higher no parking cost was anticipated. (Ref 2, P 196	Not documented	Not documented	Not documented	
Transit fare	Zone to zone Transit fares are developed for the 22 paths sets in the transit skimming. The purpose of transit fare process is to develop a zonal matrix containing total transit costs as expressed in 2007 cents. (Ref 2, P 141 and P 143)	Flat rate of $1.5 is used for all bus and rail lines (Ref 10, page 258)	Zone to zone Transit fares are developed for the 22 paths sets in the transit skimming. The purpose of transit fare process is to develop a zonal matrix containing total transit costs as expressed in 2007 cents. (Ref 2, P 141 and P 143)	N/A	N/A	N/A	
Toll	Toll is dynamically set based on congestion levels. The toll is set such that the HOT lanes will remain free flowing (Ref 2, P 31)	Toll diversion model to account for toll roads. This model converts toll costs to toll penalties using value of time factors. (Ref 10, page 229)	Toll is dynamically set based on congestion levels. The toll is set such that the HOT lanes will remain free flowing (Ref 2, P 31)	The link-based toll scenario input table is used to define tolling conditions on a road segment in the simulation. Currently, there are three classes defined for different toll pricing – SOV, HOV, and trucks. (Ref 9, page 39)	The link-based toll scenario input table is used to define tolling conditions on a road segment in the simulation. Currently, there are three classes defined for different toll pricing – SOV, HOV, and trucks. (Ref 7, P 53)	The link-based toll scenario input table is used to define tolling conditions on a road segment in the simulation. Currently, there are three classes defined for different toll pricing – SOV, HOV, and trucks. (Ref 9, page 39)	
Time of Day							
Periods	AM Peak (6:00 AM – 9:00 AM), Mid- Peak (9:00 AM – 3:00 PM), PM Peak (3:00 PM – 7:00 PM), Nighttime/early morning (7:00 PM – 6:00 AM) (Ref 2, Page 26)	AM Peak (6:00 AM – 10:00 AM), Mid- Peak (10:00 AM – 3:00 PM), PM Peak (3:00 PM – 7:00 PM), Nighttime/early morning (7:00 PM – 6:00 AM) (Ref 10, Page 229)	AM Peak (6:00 AM – 9:00 AM), Mid- Peak (9:00 AM – 3:00 PM), PM Peak (3:00 PM – 7:00 PM), Nighttime/early morning (7:00 PM – 6:00 AM) (Ref 2, Page 26)	Varies depending on application but models can simulate multiple time periods. Generally used to evaluate peak period conditions	Varies depending on application but models can simulate multiple time periods. Generally used to evaluate peak period conditions	Varies depending on application but models can simulate multiple time periods. Generally used to evaluate peak period conditions	
Peaking factors	Time of day factors adjusted in MWCOG Version 2.3 and Travel 4 to better match observed peak period VMT Ref 4, page 7-1)	More time periods are used which allows better modeling of the shoulders of the peak (Ref 8, slide 47)	Time of day factors adjusted in Version 2.3 to better match observed peak period VMT Ref 4, page 7-1)	Peak period traffic counts used to re-estimate OD table which in turn captures peaking characteristics of counts (Ref 9, page 21)	Peak period traffic counts used to re-estimate OD table which in turn captures peaking characteristics of counts (Ref 9, page 21)	Peak period traffic counts used to re-estimate OD table which in turn captures peaking characteristics of counts (Ref 9, page 21)	

SUMMARY OF TRAVEL FORECASTING METHODS FOR M-NCPPC

Topic Area	TRAVEL/4	Bill Allen's Simplified Tour Based Model	MWCOG	UMD mesoscopic model	DTA Lite	Agent Based Model	Comments
Peak spreading	Not captured in assignment process	Logit models by tour direction and purpose used for Time of Day with input variables HH income, life cycle, O-D Time, O and D area types and number of stops. This and more time periods improves the ability to model peak spreading (Ref 8, slide 47)	Not captured in assignment process	Peak spreading captured through time dependent OD matrices used in assignment. Agent based choice models used to model drivers changes in routing and time of departure which allows peak spreading to be explicitly evaluated (Ref 9, page 21)	Peak spreading captured through time dependent OD matrices used in assignment. Agent based choice models used to model drivers changes in routing and time of departure which allows peak spreading to be explicitly evaluated (Ref 9, page 21)	Peak spreading captured through time dependent OD matrices used in assignment. Agent based choice models used to model drivers changes in routing and time of departure which allows peak spreading to be explicitly evaluated (Ref 9, page 21)	DTA models in general will model peak period an peak spreading behavior better than static planning models
Feedback Mechanisms							
Feedback Process	A speed feedback (SFB) loop is used. (Ref 4, page 8-6)	ARC Regional travel demand model utilizes a feedback model option from highway assignment back to trip generation. The AM peak skims which are representative of peak travel are used in the feedback process. (Ref 10, page 234)	A speed feedback (SFB) loop is used. (Ref 4, page 8-6)	Not documented	Not documented	Not documented	
Convergence	There is no stopping criteria used for testing convergence of SFB loop. It was determined that the model is sufficiently converged after four SFB iterations. A fixed number of SFB loop iterations (five iteration, including the initial iteration, known as the "pump prime" iteration (Ref 2, P 25)	Varies depending on modeled region	There is no stopping criteria used for testing convergence of SFB loop. It was determined that the model is sufficiently converged after four SFB iterations. A fixed number of SFB loop iterations (five iteration, including the initial iteration, known as the "pump prime" iteration) (Ref 2, P 25)	Convergence not documented but listed as a challenge for larger networks	Convergence not documented but listed as a challenge for larger networks	Convergence not documented but listed as a challenge for larger networks	
Goods Movement							
Incorporation	Truck and commercial vehicle models incorporated along with airport passenger model (Ref 4, page 1-7)	Tour based Truck model incorporated into Charlotte and Atlanta models (Ref 8, slide 49)	Truck and commercial vehicle models incorporated along with airport passenger model (Ref 4, page 1-7)	Truck trip tables from regional model can be used in assignment (Ref 9, page 12)	Truck trip tables from regional model can be used in assignment (Ref 7, page 6)	Truck trip tables from regional model can be used in assignment (Ref 9, page 12)	
Truck traffic	Truck traffic is assigned via Truck OD table to highway network (Ref 4, page 8-3)	Truck traffic is assigned via Truck OD table to highway network. OD table deconstructed from Truck trip tours (Ref 8, slide 50)	Truck traffic is assigned via Truck OD table to highway network (Ref 4, page 8-3)	Truck trip tables from regional model can be used in assignment (Ref 9, page 12)	Truck trip tables from regional model can be used in assignment (Ref 7, page 6)	Truck trip tables from regional model can be used in assignment (Ref 9, page 12)	
Model Administration							
Development/User Report	Travel 4 includes Model Validation report only at this time	No documentation given User guide available on ARC web site.	Users guide available on MWCOG website	No documentation given	No documentation given	No documentation given	
Model Working Group	No working group currently	Varies depending on modeled region	Technical Committee Group	No working group currently	No working group currently	No working group currently	
User Agreement	No documentation given	Varies depending on modeled region	Written request to MWCOG required to obtain model files	No documentation given	Free, open source software	No documentation given	
Model Interface/Presentation	Cube Voyager (Ref 4, page 8-1)	Cube Voyager but can work in Fortran, C++, BASIC, Python (Ref 8, slide 52)	Cube Voyager (Ref 4, page 8-1)	Transmodeler (Ref 9, page 11)	NEXTA visualization package (Ref 7, page 3)	Transmodeler (Ref 9, page 11)	

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Miscellaneous							
Induced Travel	Captured to some degree in mode choice and assignment	Captured to some degree in mode choice, assignment, and also Time of Day. The effect of induced travel comes directly from households locating in areas where transit and walking are not viable options, thus causing greater car ownerships, and thus creating more trips. 9Ref 10, page 15)	Captured to some degree in mode choice and assignment	Minimally captured in dynamic assignment	Minimally captured in dynamic assignment	Minimally captured in dynamic assignment	Integrated land use/transportation model required to better capture induced travel as a function of improved accessibility

References:

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3. Regional Transportation Model conversion to Travel/4 Model Validation Report, VHB, July 31, 2015.
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6. DTALite: An Open- Source Fast Dynamic Traffic Assignment Engine (https://sites.google.com/site/dtalite/project-definition)
7. Data Structure and Workflow of DTALite/NexTA
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9. MD-13-SP109B4P Project Final Report
10. ARC Travel Forecasting Model set for the Atlanta region 2010 documentation
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12. ARC Travel Forecasting Model set for the Atlanta region 2010 users guide
13. Metrolina Regional Travel Demand Model 2040 Metropolitan Transportation Plan
14. ARC presentation by Guy Rousseau on Feedback loops