2025 Fall NCMUG Meeting

Introduction of North Carolina Regional Travel Demand Model Framework

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Overview

- **NCRTDM Development Guidelines**
- **NCRTDM Development for Regions**
- **Visitor Model Development**
- **CAV Model Development**

Regional Travel Demand Model Development Guidelines

North Carolina Department of Transportation

Transportation Planning Division

September 13, 2021

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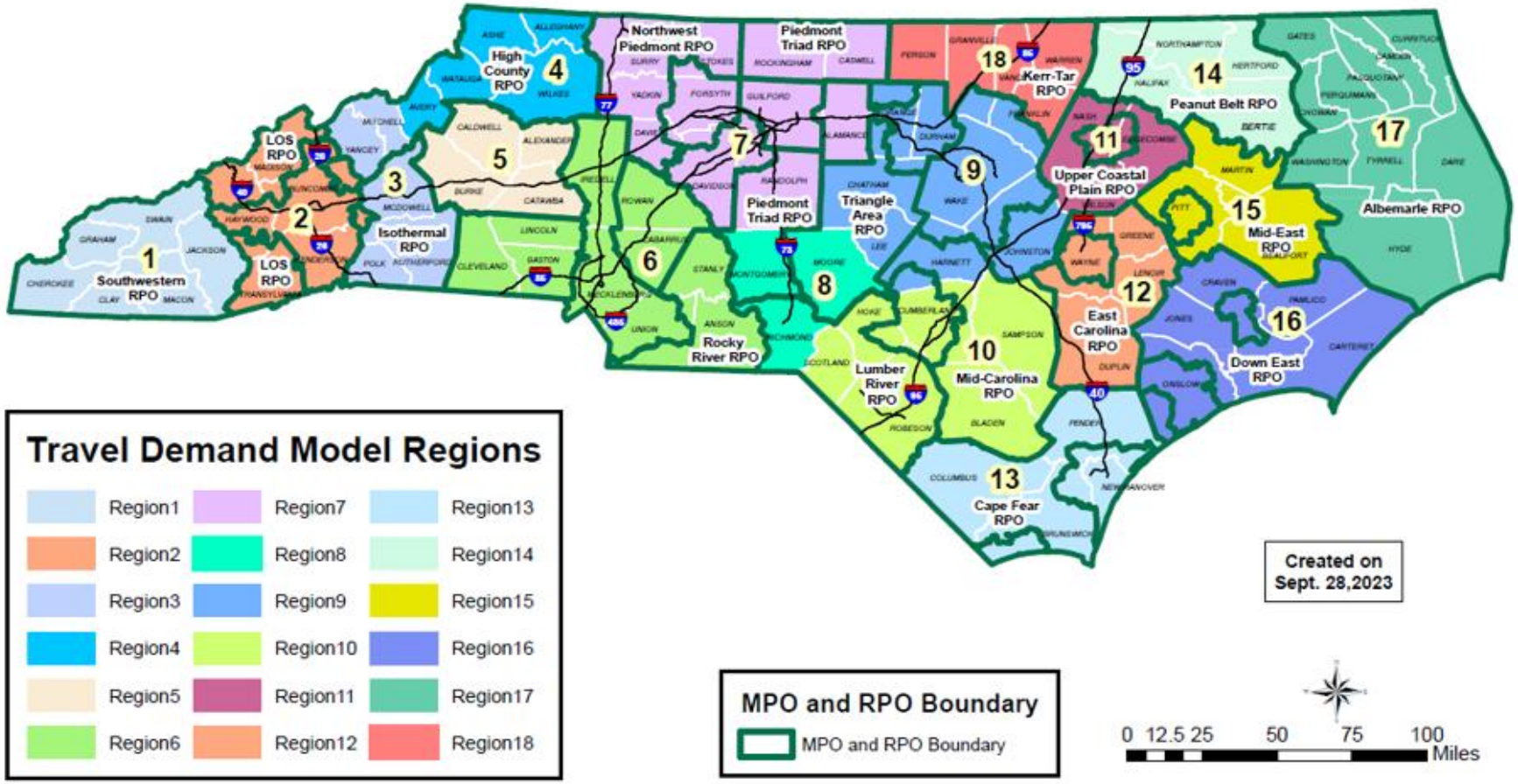
NCRTDM Development Program

- **Objectives**
  - Standard modeling process for regions under NCDOT jurisdiction
  - Model structure sensitive to region type as MPO vs. Non-MPO
  - Customized to needs of each region

- **Benefits**
  - Standard structure facilitates staff efficiency
  - Transferability of parameters and routines
  - Facilitate transition to advanced features as regions grow

Travel Demand Model Regions in NC



NCRTDMs for all Regions except:

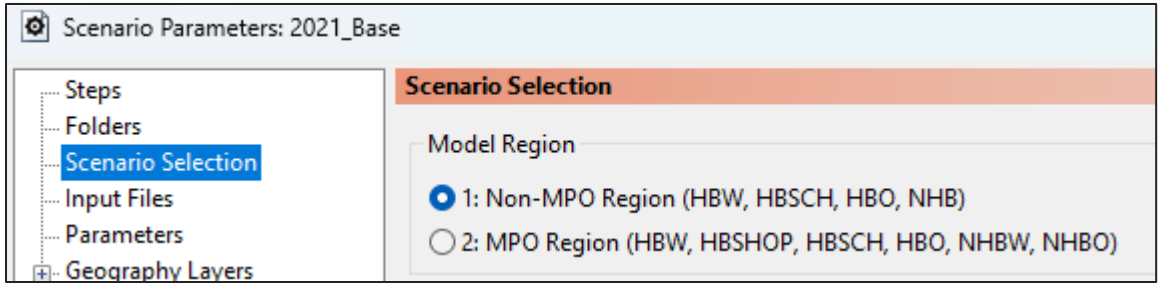
- Charlotte (MRM)
- Raleigh (TRM)
- Piedmont Triad (PTRM)

Model Steps and Types

Model Step	Regional Travel Demand Model Type	
	MPO	Non-MPO
Major Trip Purposes	HBW, HB Shopping, HB School, HBO, NHB Work, and NHB Other	HBW, HB School, HBO, and NHB
Household Stratification	Size (Persons/Workers), Income, Life cycle, Vehicle type availability (Conventional, CAV)	Size (Persons/Workers), Income, Life cycle, Vehicle type availability (Conventional, CAV)
Trip Generation	Cross-Classification for production & Zonal Attraction Equations for NHB purposes	Cross-Classification for production & Zonal Attraction Equations for NHB purposes
Non-Motorized Trip Estimation	Post Generation Logit Model - Based on Urban Form, Density, Network	Post Generation Logit Model - Based on Urban Form, Density, Network
External Trip Estimation	Options Specified (Passive data, NCSTM) & Synthetic Process	Options Specified (Passive data, NCSTM) & Synthetic Process
Commercial Vehicle Estimation	Adoption of standard truck model (e.g., NCSAM) for light, medium, & heavy trucks	Adoption of standard truck model (e.g. NCSAM) for light, medium, & heavy trucks
Path-Building	Highway and Transit	Highway
Trip Distribution	Destination Choice model (Multi-modal Impedance)	Destination Choice model (Highway Impedance)
Mode Choice	Nested logit choice model (DA, Shared2+, CAV, Local Bus)	Specified mode shares (DA, Shared2+, CAV)
Conversion of Auto Trips from Person to Vehicle	Occupancy rates by trip purposes	Occupancy rates by trip purposes
Time-of-Day and Trip Conversion from P-A to O-D	Four time periods (AM peak, mid-day, PM peak, night)	Four time periods (AM peak, mid-day, PM peak, night)
Highway Assignment	Preloading for external trips & MMA for internal trips (SOV, HOV2+, medium truck, heavy truck)	Preloading for external trips & MMA for internal trips (auto, medium truck, heavy truck)
Transit Assignment	Peak & Off Peak	Not Applicable
Feedback Process	Yes	No

Key Difference by Region Type

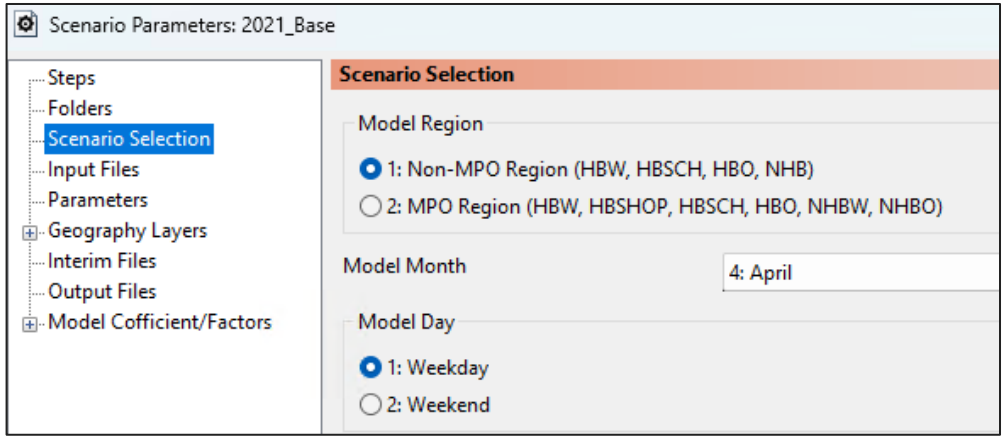
- **Non-MPO**
  - Four trip purposes
  - Highway only
- **MPO**
  - Six trip purposes
  - Transit included
  - Feedback Processing



Special Requests for Modeling (1/2)

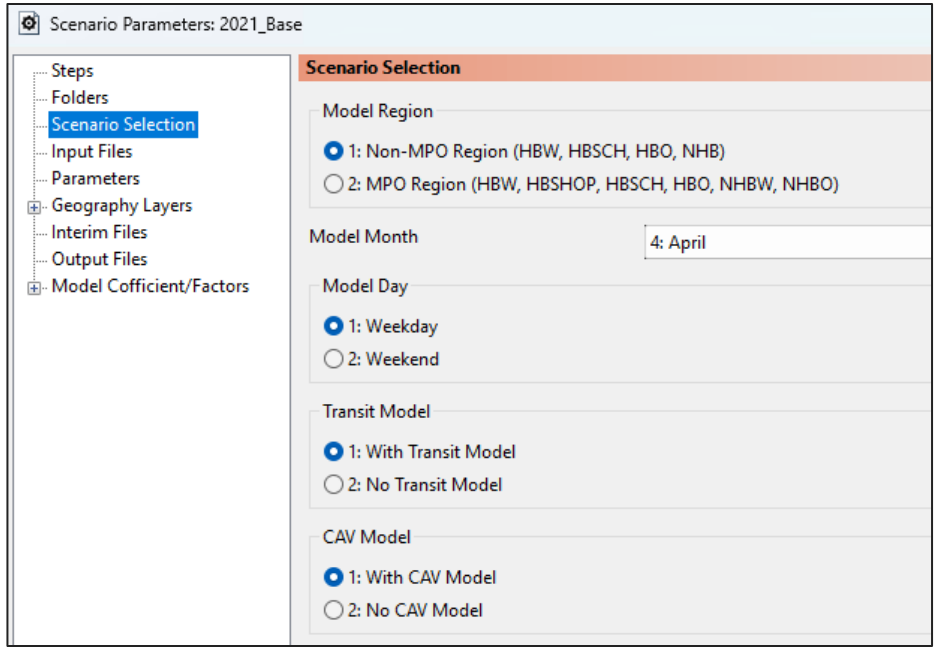
- **Connected and Autonomous Vehicle (CAV) Model**
  - Highway capacity adjustment
  - Zero occupant vehicles

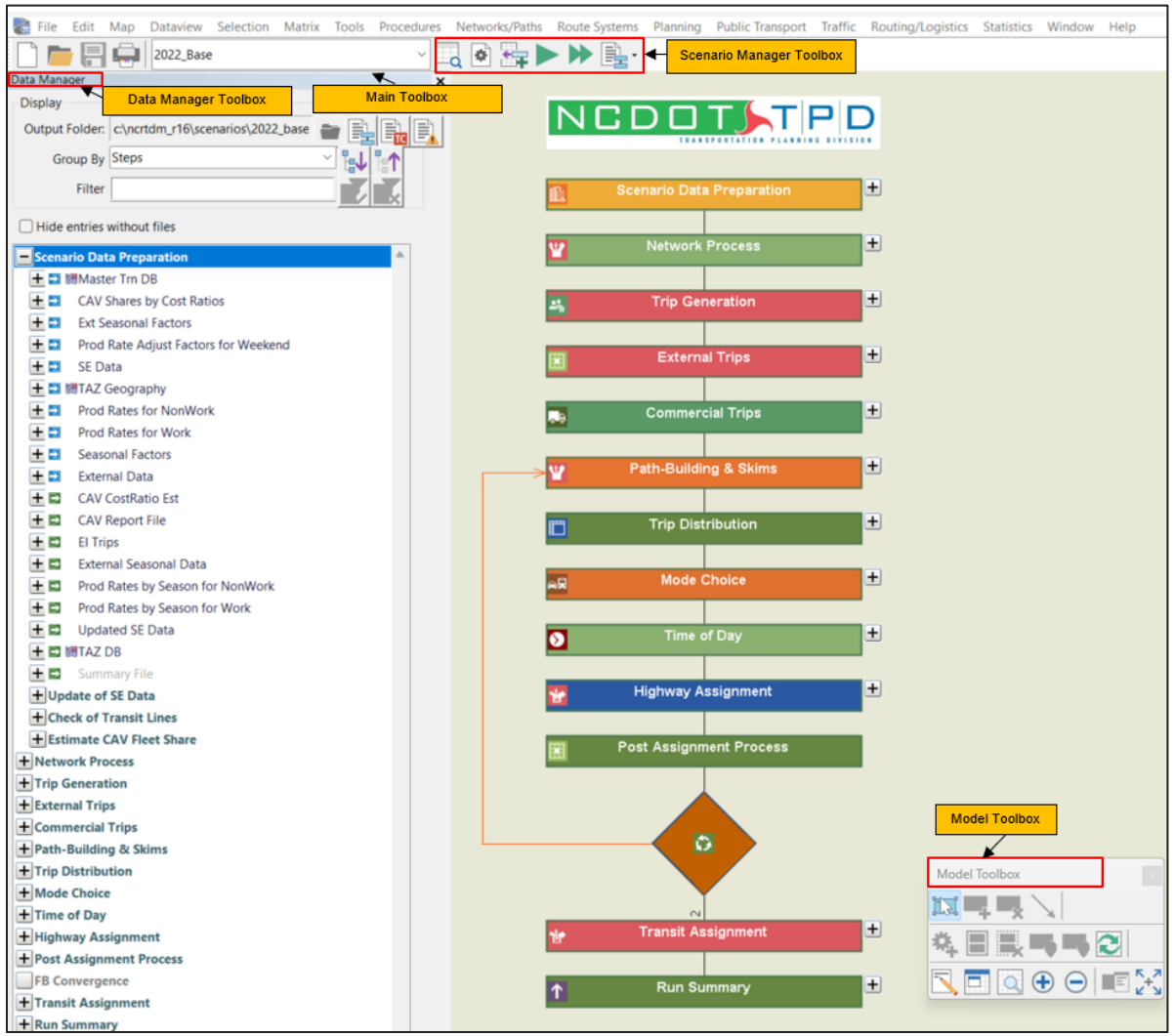
- **Visitor Model**
  - Day-trip access-journey
  - Overnight-stay access-journey
  - Season-based and day-based scenarios
  - Rental home/condo and Hotel/motel
  - At-location activities (e.g., eating, shopping, events)



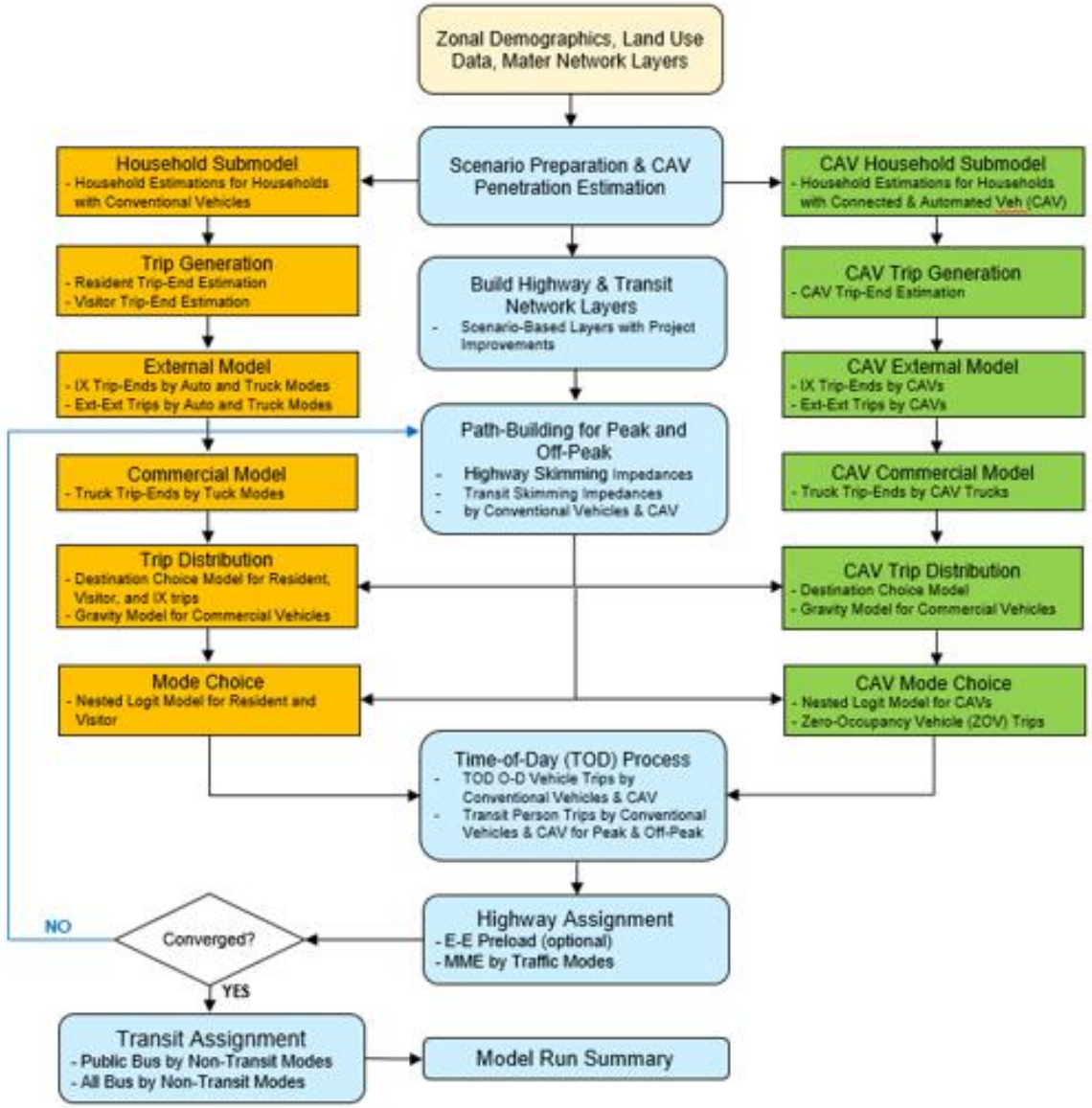
Special Requests for Modeling (2/2)

- **TransCAD Program**
  - Latest TransCAD version 9.0 Build 32855 (also work in 32960)
  - Flowchart-based user interface

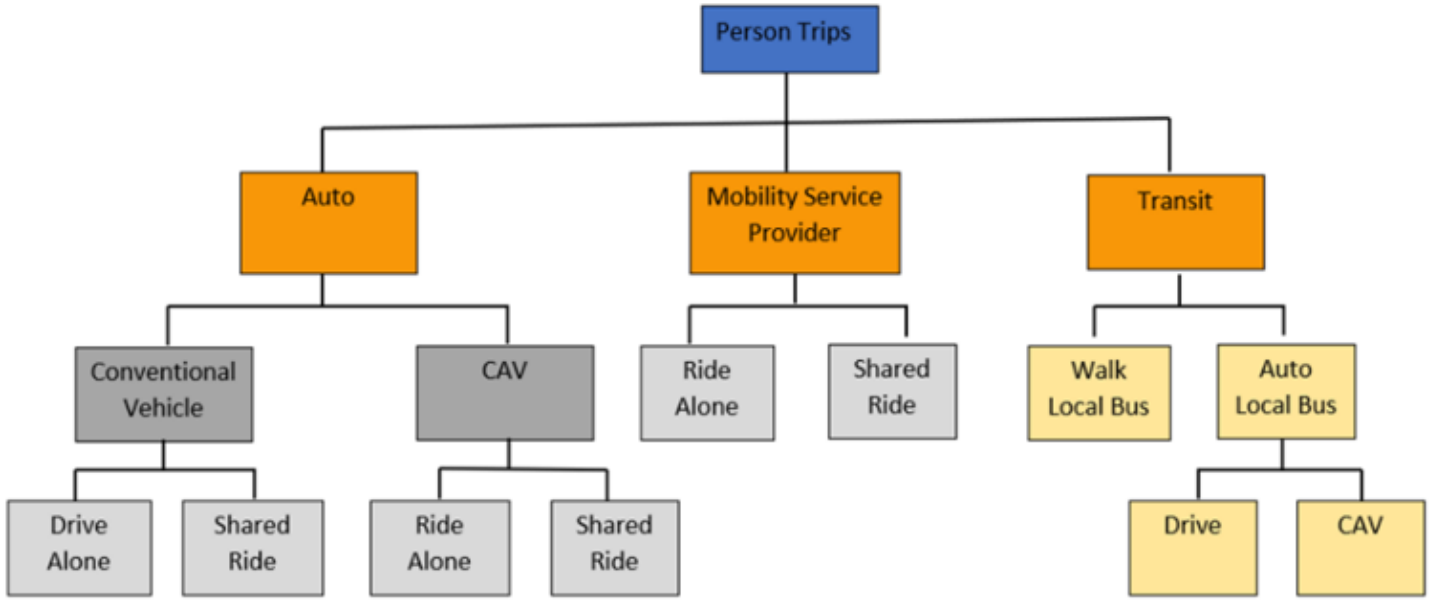




NCRTDM Structure Diagram



Mode Choice Structure



Mode Availability by Access Condition

Access Condition	Household Category	Privately Owned Vehicles				MSP		Transit		
		Conventional Vehicles		CAVs						
		Drive Alone	Shared Ride	Ride Alone	Shared Ride	Ride Alone	Shared Ride	Walk Access	Conventional Vehicle	CAV
Walk Access	Conventional Vehicles	•	•			•	•	•	•	
	CAV	•	•	•	•	•	•	•	•	•
Drive Access	Conventional Vehicles	•	•			•	•		•	
	CAV	•	•	•	•	•	•		•	•
No Transit	Conventional Vehicles	•	•			•	•			
	CAV	•	•	•	•	•	•			

Regional Travel Demand Model Development for Region 17

North Carolina Department of Transportation
Transportation Planning Division

September 15, 2023

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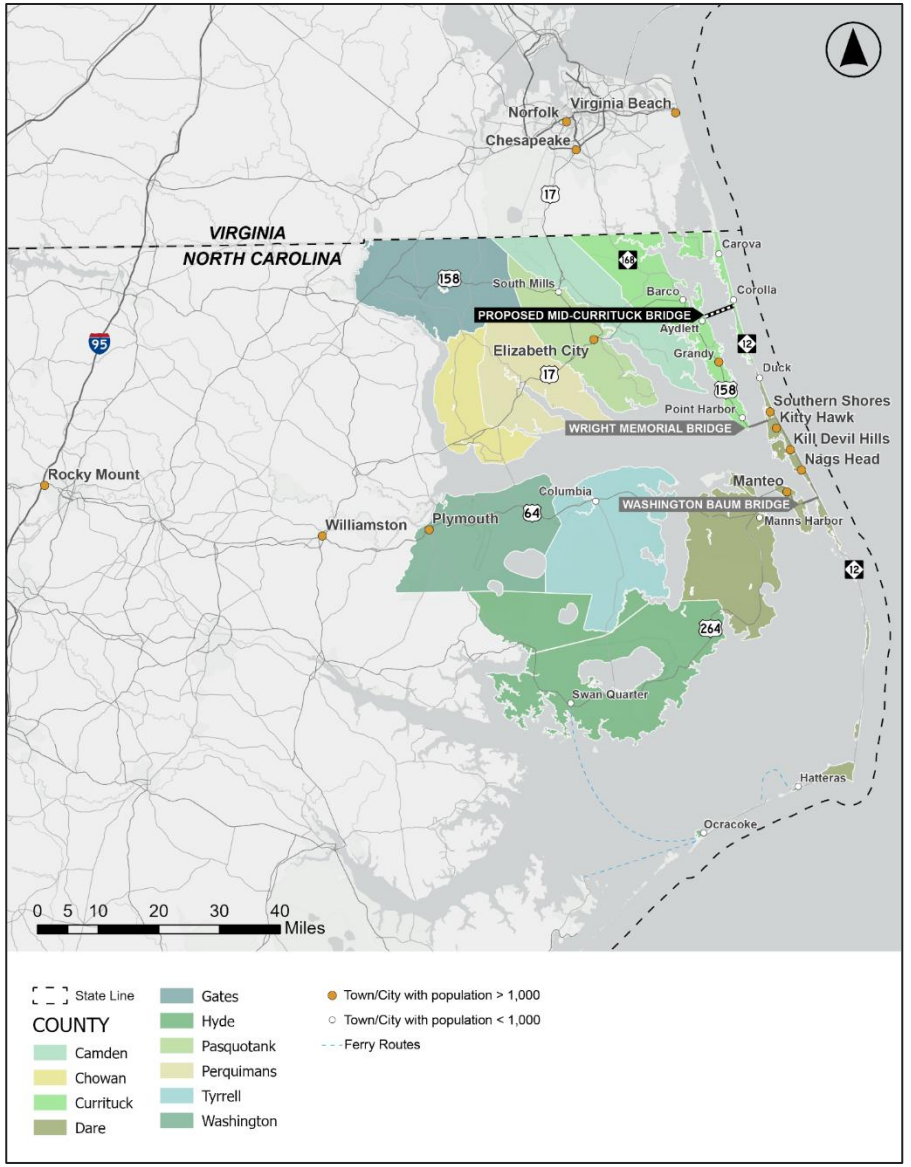
Overview for Region 17

- **Key Characteristics**
  - Largely rural
  - Interaction with large attractors outside of region
  - Significant seasonal travel
  - Significant seasonal employment

- **Main Bridges**
  - Wright Memorial Bridge
  - Washington Baum Bridge
  - Proposed Mid-Currituck Bridge



Highway and Transit Networks

- **Master Networks for Highway and Transit**
  - Source: NCDOT GIS shape layer
  - Including future project improvements

- **Highway Speed and Capacity Process**
  - Option 1: Hourly lane capacity and speed lookup tables
  - Option 2: HCM-based computation

- **Transit Network Process**
  - Transit operating time based on highway congested time
  - Transit walk-access coverage

Household Submodel

- **Methodology**
  - Joint distribution process
- **Input Data**
  - Household distributions
  - 3 income groups, 5 household sizes, 4 worker groups, and 3 life cycle groups (retired, with children, no child)
- **Output Results**
  - Households by each category for each TAZ

Trip Generation

- **Methodology**
  - Cross-classification for trip production
  - Linear regression for trip attraction

- **Input Data**
  - Trip production rates by trip purposes
  - Coefficients for linear regression model
  - Demographic data

- **Output Results**
  - Trip productions and trip attractions by trip purposes

Trip Distribution

- **Methodology**
  - Destination choice model

- **Input Data**
  - Trip productions and trip attractions by trip purposes
  - Coefficients for utility functions by trip purposes
  - Skimming impedances for generalized costs

- **Output Results**
  - Production-attraction person trips by trip purposes

External Trips

- **Methodology**
  - External trips – by input AWDT and traffic shares
  - E-I attraction - using a power function with travel time
  - E-E trips – application of seed matrix obtained from StreetLight
  - Distribution – Destination Choice Model
- **Input Data**

Field Name	Type	Description	Value
Zone	Integer	External zone (station) number	3001 – 3053
County_FP	Character	County FIPS code	3-digits
County_Name	Character	County name	
Route	Character	Highway road name at external station	
Fccode	Character	Functional classification at external station	
ADT_Base	Real	Average weekday vehicle traffic (April Weekday)	
Ext_P_Auto	Real	Proportion of auto traffic in ADT (Average weekday vehicle traffic)	0.0 – 1.0
Ext_P_MTrk	Real	Proportion of medium truck traffic in ADT (Average weekday vehicle traffic)	0.0 – 1.0
Ext_P_HTrk	Real	Proportion of heavy truck traffic in ADT (Average weekday vehicle traffic)	0.0 – 1.0
EE_P_Total	Real	Proportion of Ext-Ext vehicle traffic in ADT (Average weekday vehicle traffic)	0.0 – 1.0
EE_P_Auto	Real	Proportion of auto traffic in total Ext-Ext vehicle traffic	0.0 – 1.0
EE_P_MTrk	Real	Proportion of medium truck traffic in total Ext-Ext vehicle traffic	0.0 – 1.0
EE_P_HTrk	Real	Proportion of heavy truck traffic in total Ext-Ext vehicle traffic	0.0 – 1.0
GW_Share	Real	Visitor gateway traffic share	0.0 – 1.0

- **Output Results**
  - External trip-ends
  - E-E trip matrices
  - External O-D trips

Commercial Vehicle Trips

- **Methodology**
  - Application of truck rates by employments
  - Distribution – Gravity Model

- **Input Data**
  - Trip attraction rates by light truck (2-axle 4-tire), medium truck (2-axle 6-tire), and heavy truck (3+ axles)
  - Employment data
  - Highway skimming impedances

- **Output Results**
  - Truck trip-ends
  - Truck O-D trips

Mode Choice

- **Methodology**
  - Nested logit model

- **Input Data**
  - Production-attraction person trips by trip purposes
  - Coefficients for utility functions by trip purposes
  - Skimming impedances for auto and transit

- **Output Results**
  - Production-attraction person trips by traffic modes for trip purposes

Time-of-Day (TOD)

- **Methodology**
  - Application of TOD factors for highway trips
  - AM (6-9am), MD (9am-3pm), PM (3pm-6pm), NT (6pm-6am)
  - No TOD process for transit trips

- **Input Data**
  - Time-of-day factors by trip purposes for highway
  - Vehicle occupant rates by trip purposes

- **Output Results**
  - TOD Origin-Destination (O-D) vehicle trips by traffic modes in highway
  - Production-attraction person trips for peak and off-peak

Highway Assignment (1/2)

- **Methodology**
  - Multi-modal Multi-class Assignment (MMA)
  - All-or-nothing (AON) for E-E trips (pre-loading process)

- **Input Data**
  - Highway network and O-D trips
  - Turn penalty, truck prohibition, and link performance function

- **Output Results**
  - TOD highway assigned volumes by traffic modes
  - TOD congested speeds
  - VMT and VHT for each highway link

Highway Assignment (2/2)

- **Output Results**

Link Field Name[1]	Description
PKTime	Peak link travel time (min)
OPTime	Off-peak link travel time (min)
HourCapD	Hourly capacity per lane for LOS D
HourCapE	Hourly capacity per lane for LOS E
##CapD	Link capacity for each time period (##) for LOS D
##Cap	Link capacity for each time period (##) for LOS E
Preload_##	Pre-assigned link volumes by E-E trips for each time period (##)
##_CapAdj	Link capacity adjusted by CAV for each time period (##)
##_TimeAdj	Congested time (min) adjusted by CAV for each time period (##)
Time_##	Congested time (min) for each time period (##)
Speed_##	Congested speed (mph) for each time period (##)
VC_##	Volume/Capacity ratio for each time period (##)
VMT_##	Vehicle miles traveled (veh-miles)
VHT_##	Vehicle hours traveled (veh-hours)

Notes:

(1) TransCAD provides variables by direction (AB &BA)

(2) ## = AM, MD, PM, or NT

Transit Assignment (1/2)

- **Methodology**
  - TransCAD Pathfinder method
- **Input Data**
  - Transit route system and underlying layer
  - Transit person trips for peak and off-peak
- **Output Results**
  - Boarding and alighting by each transit route and each stop
  - Transit ridership flows by each route segment between two stops
  - Non-transit access flows in highway links

Transit Assignment (2/2)

- **Output Results**

File Name	Description
Trn_WKBUS_PK_ConvVeh_ONO.bin	Transit boarding & alighting at each stop for peak walk-access bus
Trn_WKBUS_OP_ConvVeh_ONO.bin	Transit boarding & alighting at each stop for Off-peak walk-access bus
Trn_CONVBUS_PK_ConvVeh_ONO.bin	Transit boarding & alighting at each stop for peak drive-access bus
Trn_CONVBUS_OP_ConvVeh_ONO.bin	Transit boarding & alighting at each stop for off-peak drive-access bus
Trn_WKBUS_PK_CAV_ONO.bin	Transit boarding & alighting at each stop for peak walk-access bus for CAV trips
Trn_WKBUS_OP_CAV_ONO.bin	Transit boarding & alighting at each stop for Off-peak walk-access bus for CAV trips
Trn_CONVBUS_PK_CAV_ONO.bin	Transit boarding & alighting at each stop for peak drive-access bus for CAV trips
Trn_CONVBUS_OP_CAV_ONO.bin	Transit boarding & alighting at each stop for off-peak drive-access bus for CAV trips
Trn_CAVBUS_PK_CAV_ONO.bin	Transit boarding & alighting at each stop for peak CAV-access bus for CAV trips
Trn_CAVBUS_OP_CAV_ONO.bin	Transit boarding & alighting at each stop for off-peak CAV-access bus for CAV trips

File Name	Description
Trn_Assn_PKWKBUS_ConvVeh.bin	Transit link flow between stops for peak walk-access bus network
Trn_Assn_OPWKBUS_ConvVeh.bin	Transit link flow between stops for Off-peak walk-access bus network
Trn_Assn_PKDRBUS_ConvVeh.bin	Transit link flow between stops for peak drive-access bus network
Trn_Assn_OPDRBUS_ConvVeh.bin	Transit link flow between stops for off-peak drive-access bus network
Trn_Assn_PKWKBUS_CAV.bin	Transit link flow between stops for peak walk-access bus network for CAV trips
Trn_Assn_OPWKBUS_CAV.bin	Transit link flow between stops for Off-peak walk-access bus network for CAV trips
Trn_Assn_PKDRBUS_CAV.bin	Transit link flow between stops for peak drive-access bus network for CAV trips
Trn_Assn_OPDRBUS_CAV.bin	Transit link flow between stops for off-peak drive-access bus network for CAV trips
Trn_Assn_PKCAVBUS_CAV.bin	Transit link flow between stops for peak CAV-access bus network for CAV trips
Trn_Assn_OPCAVBUS_CAV.bin	Transit link flow between stops for off-peak CAV-access bus network for CAV trips

Model Feedback Process

- **Methodology**
  - RMSE for assigned volumes between prior and current iterations
  - Convergence criteria: 5% for both AM and MD
  - 10 maximum iterations
  - Applied to MPO while non-MPO doesn't have the feedback iterations

- **Output Results**

***** RMSE Values by Model Feedback Iterations *****

Iteration	AM RMSE (%)	MD RMSE (%)
1	N/A	N/A
2	8.4%	8.1%
3	1.4%	1.0%

Model Calibration & Validation Data

- **2017 NHTS Add-On Survey Data**
- **StreetLight Data**
- **American Community Survey (ACS) Data**
- **US Decennial Census Data**
- **Longitudinal Employer Household Dynamics (LEHD)**
- **2021 Traffic Counts and Observed Speed Data**

2017 NHTS Data

Number of Household Records in 2017 Household Survey Data

Area Type	NC Region			Region 17 (10 counties)		
	Weekday	Weekend	Total	Weekday	Weekend	Total
Regional Models	3,262	620	3,882			0
Non-MPO Model	971	175	1,146	65	8	73
MPO Models	1,305	238	1,543			0
Not Currently Modeled	1,879	346	2,225	210	35	245
Home out of state	14	5	19			0
Total	7,431	1,384	8,815	275	43	318

Number of Trip Records in 2017 Household Survey Data

Area Type	NC Region			Region 17 (10 counties)		
	Weekday	Weekend	Total	Weekday	Weekend	Total
Regional Models	22,122	6,319	28,441			
Non-MPO Model	6,141	1,805	7,946	336	96	432
MPO Models	8,459	2,612	11,071			
Not Currently Modeled	11,472	3,500	14,972	963	404	1,367
Home out of state	113	36	149			
Total	48,307	14,272	62,579	1,299	500	1,799

Note:

1) The area type is based on the household locations, not the origin trip location.

Model Calibration: Distribution (1/3)

- **Destination Choice Model - Average Impedance Summary**

Average Travel Time (< 101 mins)

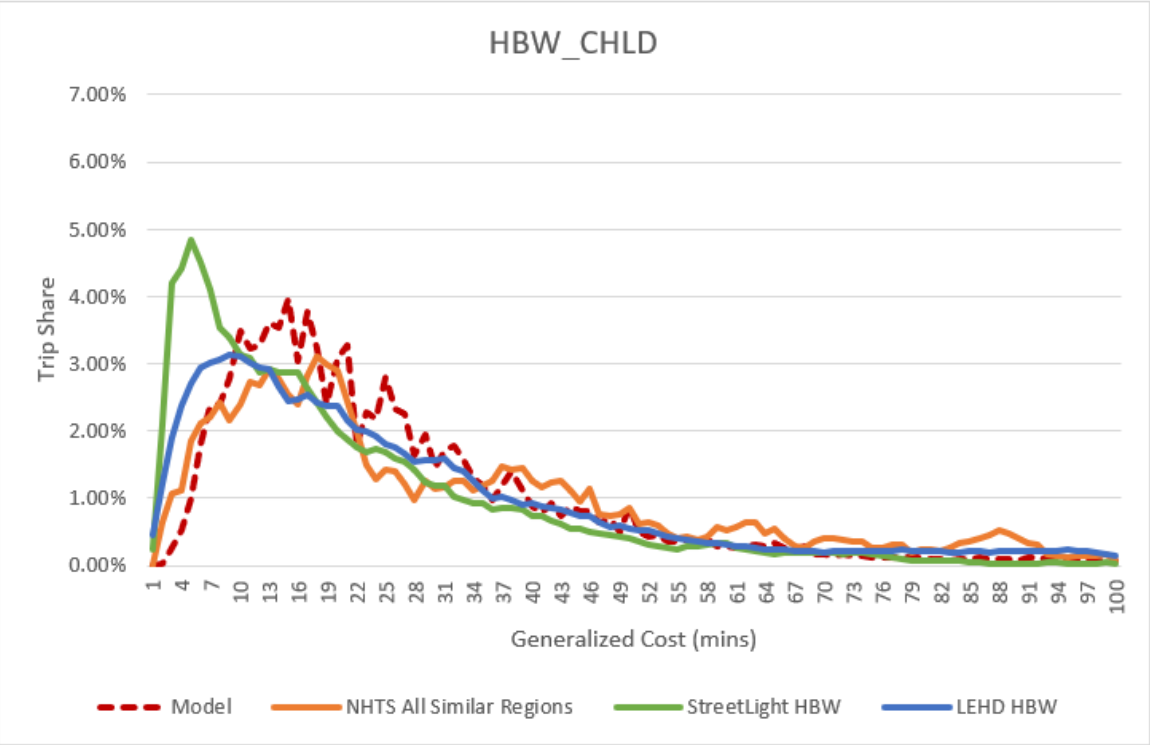
Data Type	HBW with Child	HBW with no Child	HBO with Child	HBO with no Child	NHB
LEHD	26.43				
StreetLight	15.09		16.16		15.58
NHTS Region 17	39.05	20.4	15.9	17.72	12.92
NHTS All Similar Regions	*23.80*	*23.13*	*16.88*	*18.64*	*15.23*
Model	20.35	19.17	16.39	16.66	11.43
NHTS All Similar Regions VS Model	-14.48%	-17.11%	-2.89%	-10.60%	-24.95%

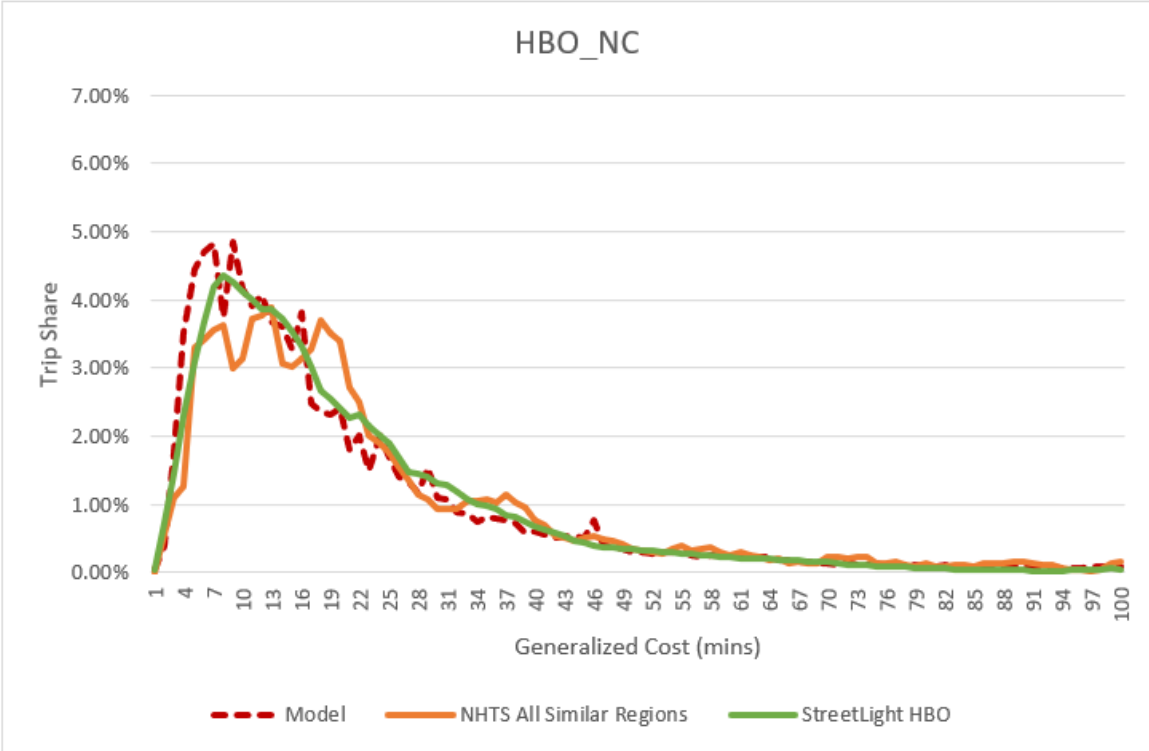
Average Distance (< 101 miles)

Data Type	HBW with Child	HBW with no Child	HBO with Child	HBO with no Child	NHB
LEHD	17.08				
StreetLight	7.67		9.04		8.52
NHTS Region 17	22.78	11.2	8.61	9.96	6.69
NHTS All Similar Regions	*13.40*	*13.58*	*8.29*	*9.29*	*7.27*
Model	11.85	10.93	10.09	10.39	6.92
NHTS All Similar Regions VS Model	-11.60%	-19.48%	21.66%	11.87%	-4.87%

Model Calibration: Distribution (2/3)

- **Destination Choice Model – Trip Length Distributions**





Model Calibration: Distribution (3/3)

- **Intrazonal Trip Percentage**

Intrazonal Trip Percentage

Target	HBW_CHLD	HBW_NC	HBO_CHLD	HBO_NC	NHB
LEHD	3.74%				
StreetLight	24.00%		10.44%		19.46%
NHTS Region 17	1.53%	19.56%	7.41%	10.85%	13.17%
NHTS All Similar Regions (Intra-Blockgroup)	*4.26%*	*10.59%*	*9.04%*	*14.01%*	*17.92%*
Model	**4.10%**	**9.00%**	**10.00%**	**13.60%**	**17.20%**
NHTS All Similar Regions VS Model	**-3.76%**	**-15.01%**	**10.62%**	**-2.93%**	**-4.02%**

Mode Choice Calibration Summary in Region 16

Trip Purpose	Income	Trips & Choice Percent	Motorized Person Trips																			
			Mode																			
			Conventional				Privately Owned CAV				MSP CAV				Transit						Total	
			Drive Alone		Shared Ride		Ride Alone		Shared Ride		Ride Alone		Shared Ride		Walk Access		Drive Access		CAV Access			
			OBS	EST	OBS	EST	OBS	EST	OBS	EST	OBS	EST	OBS	EST	OBS	EST	OBS	EST	OBS	EST	OBS	EST
HBW	1	Trips	25,425	25,530	14,417	14,293	-	0	-	0	-	14	-	0	28	49	-	-	-	-	39,870	39,886
		%	63.8%	64.0%	36.2%	35.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	2	Trips	77,824	79,078	17,815	16,544	160	189	28	11	-	18	-	0	69	52	-	-	-	-	95,896	95,893
		%	81.2%	82.5%	18.6%	17.3%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	3	Trips	76,691	77,377	10,332	9,617	724	752	26	11	-	14	-	-	-	0	-	-	-	-	87,772	87,772
		%	87.4%	88.2%	11.8%	11.0%	0.8%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	Total	Trips	179,940	181,986	42,564	40,454	884	942	54	23	-	46	-	0	96	101	-	-	-	-	223,538	223,552
		%	80.5%	81.4%	19.0%	18.1%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
HBSH	1	Trips	14,105	13,890	18,814	18,944	-	1	8	2	346	295	40	152	9	30	-	-	-	-	33,322	33,314
		%	42.3%	41.7%	56.5%	56.9%	0.0%	0.0%	0.0%	0.0%	1.0%	0.9%	0.1%	0.5%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	2	Trips	37,768	38,516	38,299	37,798	81	87	81	84	704	487	79	28	19	15	-	-	-	-	77,031	77,014
		%	49.0%	50.0%	49.7%	49.1%	0.1%	0.1%	0.1%	0.1%	0.9%	0.6%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	3	Trips	47,436	47,201	35,682	35,967	388	356	379	342	8	28	1	0	-	0	-	-	-	-	83,894	83,894
		%	56.5%	56.3%	42.5%	42.9%	0.5%	0.4%	0.5%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	Total	Trips	99,308	99,607	92,795	92,708	470	444	468	429	1,058	811	121	180	28	45	-	-	-	-	194,248	194,222
		%	51.1%	51.3%	47.8%	47.7%	0.2%	0.2%	0.2%	0.2%	0.5%	0.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
HBO	1	Trips	16,541	16,487	29,068	29,254	-	3	11	12	179	34	21	33	31	25	-	-	-	-	45,851	45,848
		%	36.1%	36.0%	63.4%	63.8%	0.0%	0.0%	0.0%	0.0%	0.4%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	2	Trips	41,144	41,339	57,366	57,462	91	57	128	132	269	59	31	2	47	23	-	-	-	-	99,076	99,075
		%	41.5%	41.7%	57.9%	58.0%	0.1%	0.1%	0.1%	0.1%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	3	Trips	46,720	46,856	57,317	57,345	432	291	508	479	8	17	3	0	-	0	-	-	-	-	104,989	104,989
		%	44.5%	44.6%	54.6%	54.6%	0.4%	0.3%	0.5%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	Total	Trips	104,406	104,682	143,751	144,061	523	351	648	623	455	110	54	35	78	49	-	-	-	-	249,916	249,912
		%	41.8%	41.9%	57.5%	57.6%	0.2%	0.1%	0.3%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
HBSCH	All	Trips	1,827	1,626	20,364	20,551	-	0	39	36	-	4	-	-	0	14	-	-	-	-	22,231	22,231
		%	8.2%	7.3%	91.6%	92.4%	0.0%	0.0%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
NHBW	All	Trips	105,664	104,877	37,615	38,416	160	208	50	54	546	442	62	88	0	14	-	-	-	-	144,098	144,099
		%	73.3%	72.8%	26.1%	26.7%	0.1%	0.1%	0.0%	0.0%	0.4%	0.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
NHBO	All	Trips	98,146	97,171	171,337	172,414	151	191	234	119	111	105	13	8	86	82	-	-	-	-	270,079	270,089
		%	36.3%	36.0%	63.4%	63.8%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
			589,291	589,949	508,427	508,605	2,188	2,136	1,494	1,283	2,171	1,517	250	311	289	305	-	-	-	-	1,104,110	1,104,105

Model Validation Process in Region 16 (1/4)

< Difference for Observed Counts vs. Estimated Volumes by Facility Types >

Facility Type	OBS Count	Observed	Estimated	DIFF	DIFF(%)	TARGET(%)
Freeway(1)	29	402,561	367,745	-34,816	-8.6%	7.0%
Multilane Highway(2)	107	918,855	952,515	33,660	3.7%	10.0%
Two-lane Highway(3)	160	474,978	493,891	18,913	4.0%	15.0%
Principal Arterial(4)	221	2,471,690	2,406,554	-65,136	-2.6%	10.0%
Minor Arterial(5)	90	490,164	502,360	12,196	2.5%	15.0%
Major Collector(6)	452	1,012,904	929,400	-83,504	-8.2%	25.0%
Minor Collector(7)	252	226,094	223,004	-3,090	-1.4%	25.0%
Local Street(8)	6	3,364	2,708	-656	-19.5%	25.0%
High Speed Ramp(9)	4	22,302	28,292	5,990	26.9%	--
Low Speed Ramp(10)	62	155,873	79,825	-76,048	-48.8%	--
Sum	1,383	6,178,785	5,986,294	-192,491	-3.1%	5.0%

(Note: Each directional observed data is counted as one location)

Model Validation Process in Region 16 (2/4)

< Observed VMT vs. Estimated VMT by Facility Types >

Facility Type	OBS Count	Observed	Estimated	DIFF	DIFF(%)	RMSE(%)
Freeway(1)	29	253,465	284,610	31,145	12.3%	47.3%
Multilane Highway(2)	107	474,995	491,907	16,913	3.6%	14.3%
Two-lane Highway(3)	160	155,951	172,317	16,366	10.5%	48.7%
Principal Arterial(4)	221	393,554	395,756	2,202	0.6%	30.4%
Minor Arterial(5)	90	56,565	55,175	-1,390	-2.5%	38.5%
Major Collector(6)	452	264,764	272,971	8,206	3.1%	63.5%
Minor Collector(7)	252	75,258	78,056	2,799	3.7%	86.9%
Local Street(8)	6	3,545	3,032	-513	-14.5%	26.6%
High Speed Ramp(9)	4	5,304	6,188	884	16.7%	37.5%
Low Speed Ramp(10)	62	33,753	20,847	-12,906	-38.2%	72.2%
Sum	1,383	1,717,153	1,780,858	63,706	3.7%	58.0%

(Note: Each directional observed data is counted as one location)

< R^2 for Estimated Volumes vs. Traffic Counts in Region >

Area	# of Counts	Modeled R^2(%)	Target R^2(%)
Regionwide	1,383	85.5%	88.0%

Model Validation Process in Region 16 (3/4)

< Percent (%) of RMSE by Volume Groups >

Volume Group	OBS Count	RMSE(%)	TARGET(%)
0 - 1,000	341	108.3%	350.0%
1,001 - 2,500	357	59.6%	120.0%
2,501 - 5,000	260	54.1%	45.0%
5,001 - 10,000	225	34.4%	40.0%
10,001 - 25,000	196	22.1%	35.0%
25,001 - 50,000	4	26.5%	30.0%
50,001 <	0	0.0%	20.0%
Sum	1,383	41.9%	35.0%

(Note: Each directional observed data is counted as one location)

Model Validation Process in Region 16 (4/4)

Transit Scheduled Run Time and Modeled Run time Comparison

Route Name	Run Time				
	Scheduled	Modeled		Diff	
	Round Trip Time	Peak Local Bus Run Time	Off - Peak Local Bus Run Time	Peak Diff	Off-peak Diff
Craven Blue Route	100	87.0	80.0	-13.0	-20.0
Craven Green Route	105	109.0	99.0	4.0	-6.0
Craven Orange Route	84	88.0	80.0	4.0	-4.0
Jacksonville Purple 101 EB	60	71.0	64.0	11.0	4.0
Jacksonville Purple 101 WB	50	64.0	59.0	14.0	9.0
Jacksonville Green 102 WB	30	32.0	30.0	2.0	0.0
Jacksonville Green 102 EB	26	33.0	30.0	7.0	4.0
Jacksonville Orange 103 EB	35	53.0	48.0	18.0	13.0
Jacksonville Orange 103 WB	25	35.0	32.0	10.0	7.0
Jacksonville Blue 104 WB	24	41.0	37.0	17.0	13.0
Jacksonville Blue 104 EB	30	36.0	33.0	6.0	3.0

Ridership by Route

Operator	Route	Average Weekday Ridership		
		Observed	Estimated	Difference
CARTS	Green	12	106	94
	Blue	32	2	-30
	Orange	9	4	-5
Jacksonville Transit	Purple	66	62	-4
	Green	76	41	-35
	Orange	53	48	-5
	Blue	20	42	22
Total		268	305	37

Horizon Years (2030, 2040, 2050) in Region 16

Trip Production Rate per Household by Scenario Year

Type	Scenario Year			
	2022	2030	2040	2050
Population (Pop)	400,257	427,841	459,752	491,193
Household (HH)	157,471	168,644	181,538	194,155
Pop/HH	2.54	2.54	2.53	2.53
Trip Production (TP)	1,127,143	1,208,404	1,302,111	1,393,266
TP/HH	7.16	7.17	7.17	7.18

Demographic and Daily VMT Summary by Scenario Year in NCRTDM Region 16

Type	Scenario Year				Growth Rate (%)		
	2022	2030	2040	2050	2022 to 2030	2030 to 2040	2040 to 2050
Population	400,257	427,841	459,752	491,193	0.8%	0.7%	0.7%
Household	157,471	168,644	181,538	194,155	0.9%	0.7%	0.7%
Employment	153,899	171,113	191,650	211,984	1.3%	1.1%	1.0%
Daily VMT (Veh-miles)	9,153,603	10,367,416	12,211,083	13,903,499	1.6%	1.7%	1.3%

Daily VMT Proportion (%) for CAV and ZOV by Scenario Year

Type	2022	2030	2040	2050
Total VMT	9,153,603	10,367,416	12,211,083	13,903,499
CAV VMT	51,823	991,442	7,048,468	11,885,613
CAV VMT/Total VMT	0.57%	9.56%	57.72%	85.49%
ZOV VMT	9,703	160,316	1,018,064	1,469,740
ZOV VMT/CAV VMT	18.72%	16.17%	14.44%	12.37%

Note:

1)ZOV: Zero Occupancy Vehicle

Visitor Model Development

Trip Purpose in Visitor Model

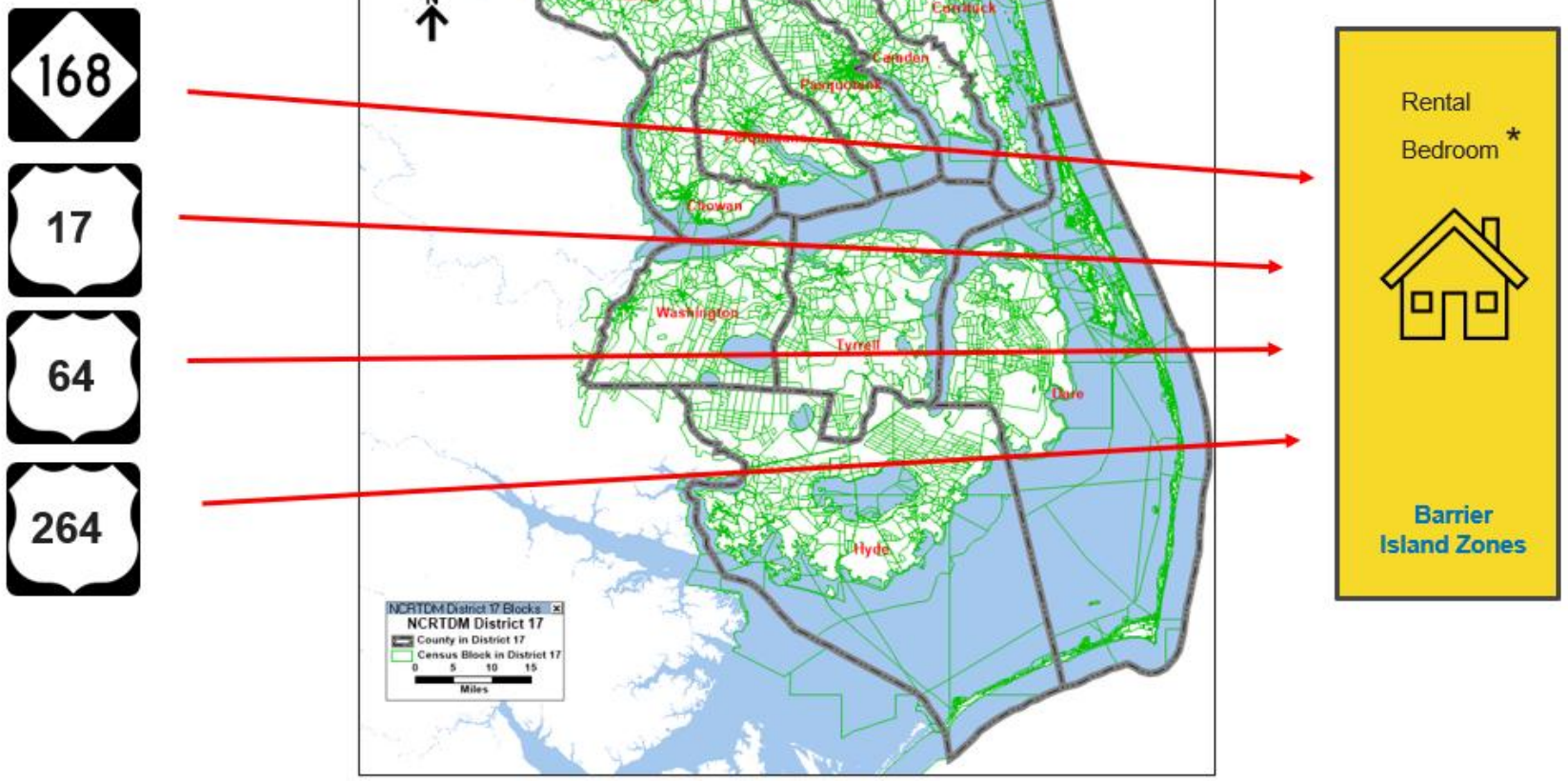
- **Access Journey: Overnight-Stay Trip Purpose**
  - Produced at Selected External Stations (NC 168, US 17, US 64, US 264)
  - Attracted to Rental Bedrooms (rental homes or hotel/motel)

- **Access Journey: Day Trip Purpose**
  - Produced at Mainland Households in Region 17
  - Attracted to Designated Beach Parking and Recreation Site Parking

- Access Journey trips applicable to Weekend Period (Saturday or Sunday)

Overnight-Stay ‘Access-Journey’ Concept

Selected External Zones



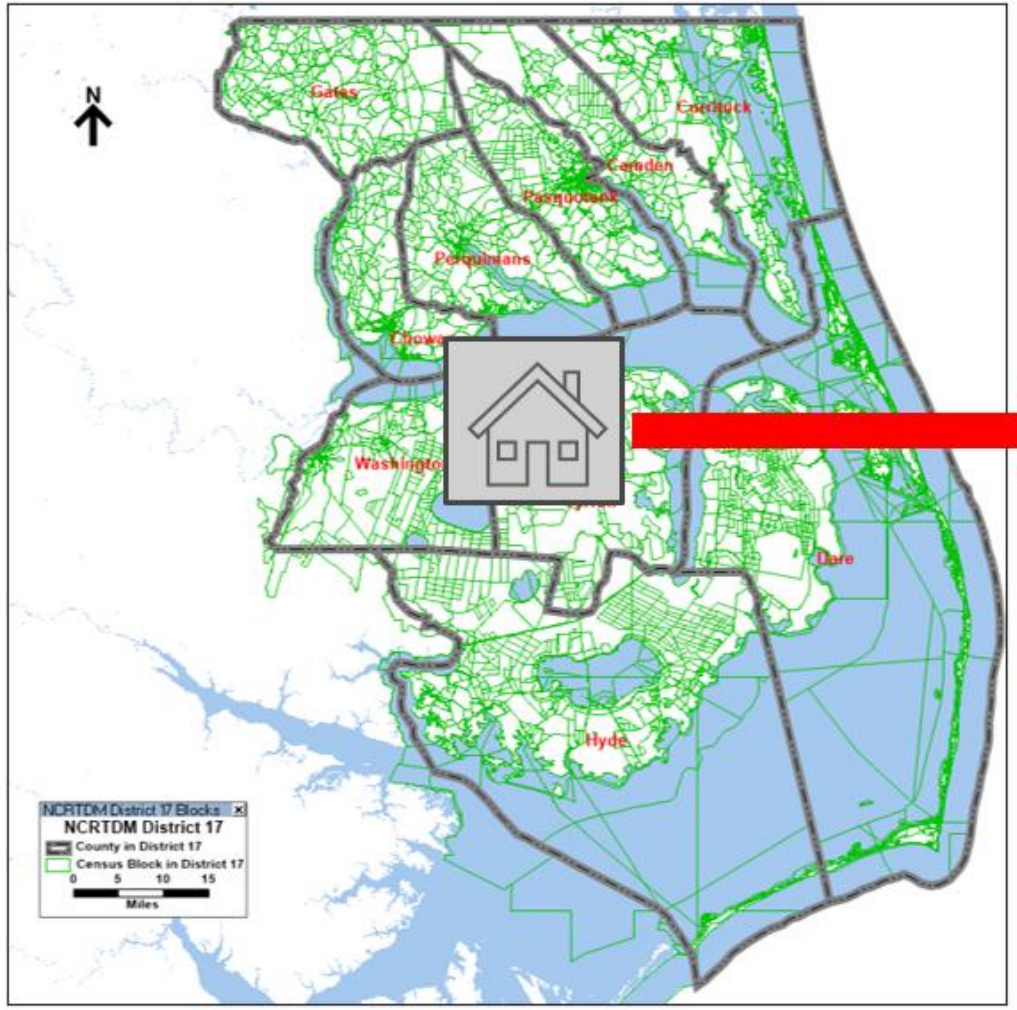
Access Journey Trips (includes Return Trips)

** Includes Hotels & Motels*

Day-Trip 'Access-Journey' Concept

Key Assumptions:

- Only Mainland Residents of Region 17 make day trips
- Attractions are Primarily Recreation Locations



Access Journey Trips
(includes Return Trips)

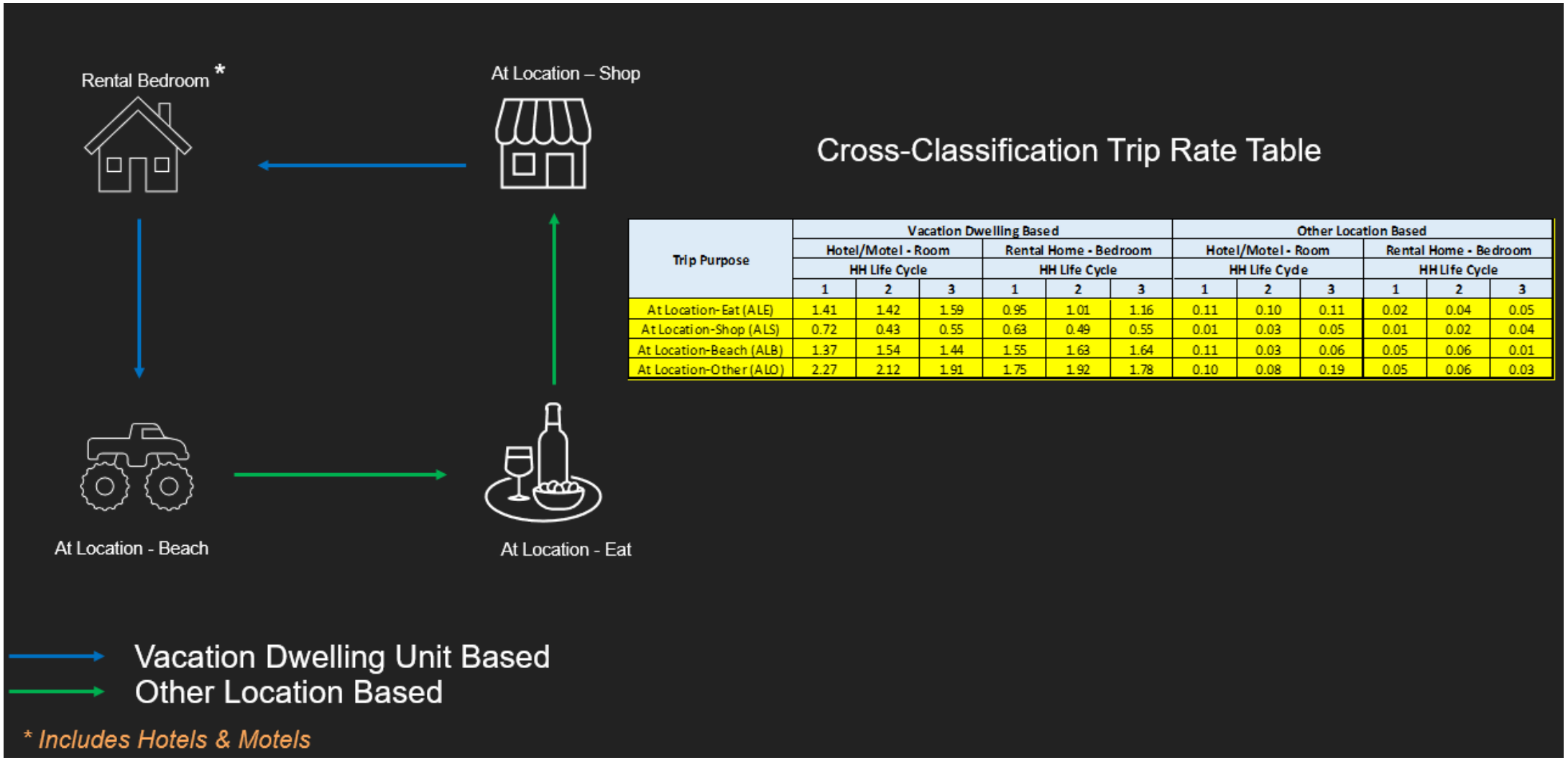
At Location Trip Purposes (1/2)

- Estimated as Motorized Person Trips
- Function of Family Life Cycle
- Overnight-Stay:
  - Some Produced at Rental Bedrooms (*similar to home-based purposes*)
  - Some Produced at Other Locations (*similar to nonhome-based purposes*)
- Day-Trip:
  - Some Produced at Designated Recreational Activity Sites (*from Access Journey*)
  - Some Produced at Other Locations
- At-Location Trips - Applicable Day of Week Periods:
  - Weekend - Both Overnight-Stay & Day-Trip Market Segments
  - Weekday - Overnight-Stay Only, No Midweek Day Trips Assumed

At Location Trip Purposes (2/2)

- **Key Recreational Activities**
  - Eat
  - Shop
  - Beach
  - Other
- **Produced at Primary Sites**
  - Vacation dwelling unit (overnight stays)
  - Selected beachfront zones (day trips)
- **Produced at Secondary Sites**
  - Employment or recreational sites

Overnight Stay ‘At-Location’ Trip Example



Cross-Classification Trip Rate Table

Trip Purpose	Vacation Dwelling Based						Other Location Based					
	Hotel/Motel - Room			Rental Home - Bedroom			Hotel/Motel - Room			Rental Home - Bedroom		
	HH Life Cycle			HH Life Cycle			HH Life Cyde			HH Life Cycle		
	1	2	3	1	2	3	1	2	3	1	2	3
At Location-Eat (ALE)	1.41	1.42	1.59	0.95	1.01	1.16	0.11	0.10	0.11	0.02	0.04	0.05
At Location-Shop (ALS)	0.72	0.43	0.55	0.63	0.49	0.55	0.01	0.03	0.05	0.01	0.02	0.04
At Location-Beach (ALB)	1.37	1.54	1.44	1.55	1.63	1.64	0.11	0.03	0.06	0.05	0.06	0.01
At Location-Other (ALO)	2.27	2.12	1.91	1.75	1.92	1.78	0.10	0.08	0.19	0.05	0.06	0.03

Day-Trip ‘At-Location’ Trip Example

Beach Zone with Public Parking

At Location – Other

At Location – Other

At Location - Eat

Trip Purpose	Initial Activity Destination			Other Location Based		
	HH Life Cycle			HH Life Cycle		
	1	2	3	1	2	3
At Location-Eat (ALE)	1.18	0.94	0.85	0.91	0.72	0.65
At Location-Shop (ALS)	0.26	0.33	0.45	0.26	0.33	0.45
At Location-Beach (ALB)	0.21	0.27	0.22	1.06	1.36	1.10
At Location-Other (ALO)	0.22	0.31	0.27	*1.11*	*1.54*	*1.33*

→ Arrival Zone Activity (Beach, Recreation, Marina)

→ Other Location Based

National Parks & Fishing Piers, and other entertainment are examples of ‘At Location-Other’ trips

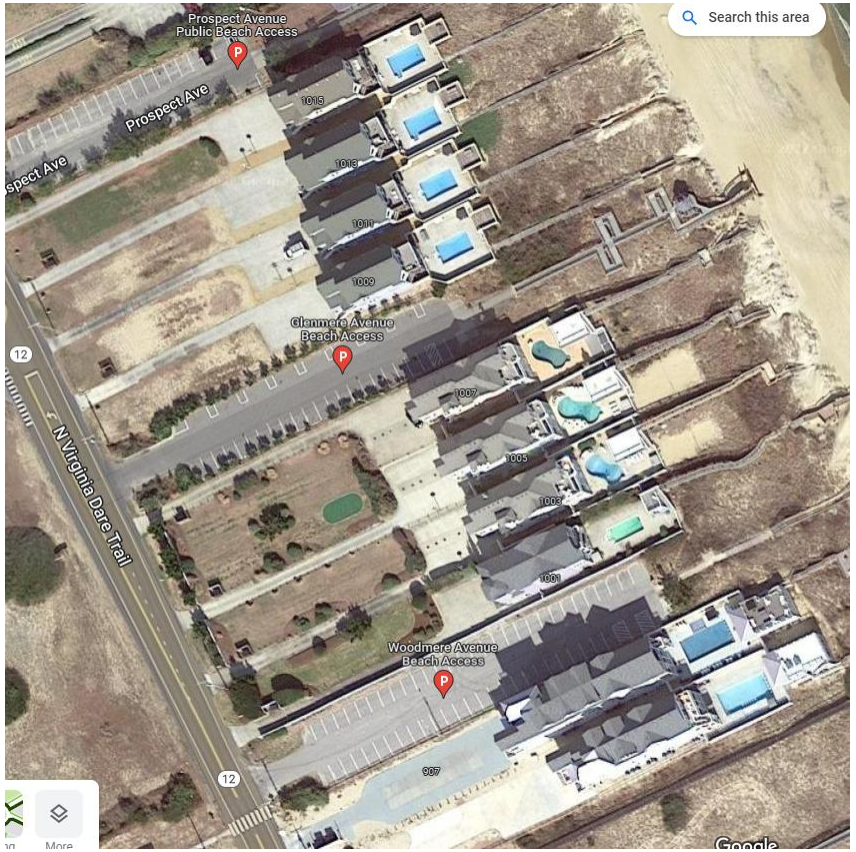
Employment Classification Refinements

- **Revised Classifications**
  - Industrial
  - Retail
  - Highway Rretail
  - Restaurant
  - Service – Weekdays
  - Service – All Days
  - Office

Employment Classification	Applicable Day Types	
	Weekday	Weekend
Industrial	✓	
Retail	✓	✓
Highway Retail	✓	✓
Restaurant	✓	✓
Service - Weekday	✓	
Service - All Day	✓	✓
Office	✓	

Parking Data Requirements

- **Designated Beachfront Zones**
  - Attractor for ‘Day-Trip’ Access trips
  - Number of spaces is attractor variable
  - Most Shore Towns have provided multiple locations
  - Also, used as attractor for ‘At-Location’ Beach trips



- **State Parks/National Parks & 4WD areas**
  - Attractor for ‘Day-Trip’ Access trips
  - Available spaces estimated by judgement

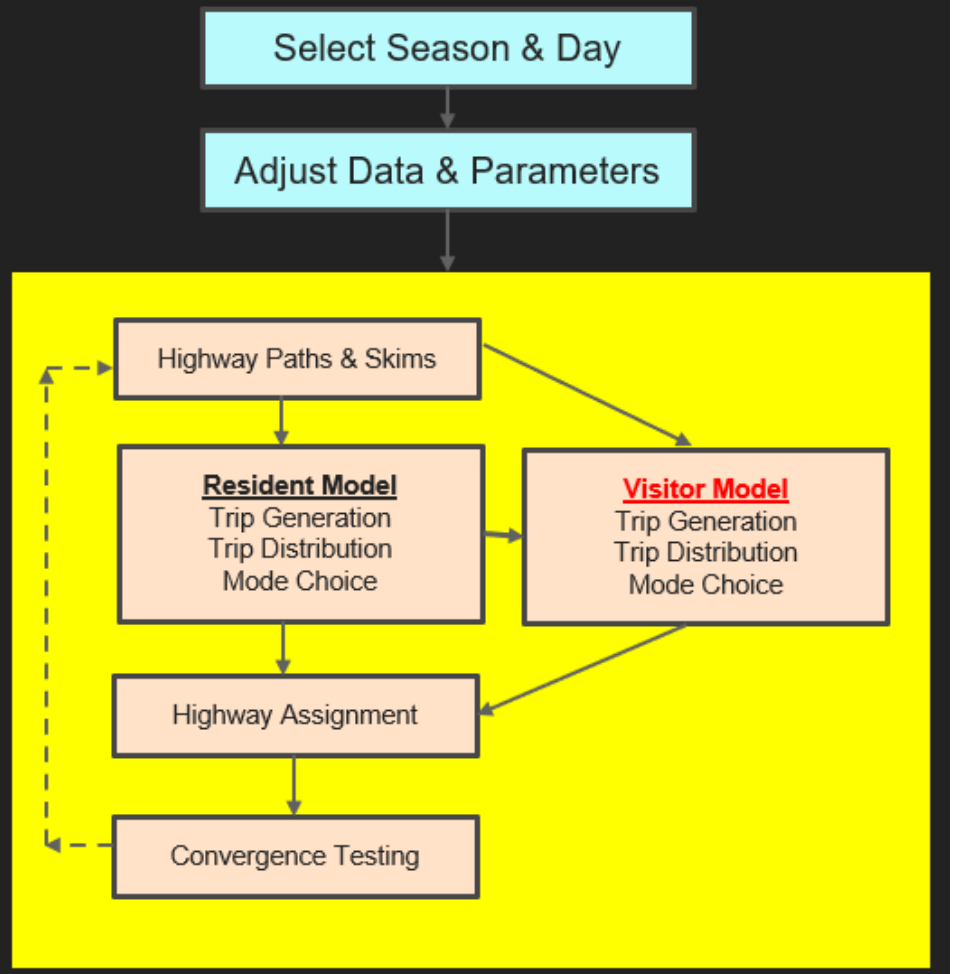
Execution Structure & Concept

Execution Process

- Execution Controlled by Month and Day Type
  - April/July – Weekday/Weekend
- Data and Parameters Adjusted for Specified Condition
  - Scaling of zonal data
  - Scaling of parameters
- Visitor Model
  - Executed only in Iteration 1
  - Requires Highway Skim Processing
  - Provides Vehicle Trips for Highway Assignment

Visitor Model Processing

- At-Location Trips have sequential processing:
  - Primary Trips Originate at Vacation Dwelling units or Specified Production zones
  - Subsequent (NHB) trips utilize Primary Trip Destinations as controlling productions



Application Concept

The Visitor Model works in a coordinated process with the Resident Model.

April – Wednesday
July - Saturday

Seasonal Scaling

- Visitor Model
  - Scales occupied rental bedrooms. This controls 'Access Journey' Trips and 'At-location' trips for overnight-stay market segment.
  - Scales parking availability for Day Trips. This controls 'Access Journey' Trips and 'At-location' trips for day-trip market segment.
- Resident Model
  - Scales seasonal employment 'layer' This controls the amount of added employment and proportionally increases HBW trip productions to match change in employment.
  - Potential adjustments to Nonwork purposes. Example, HB School purpose not active in Summer

Day-of-Week Selection

- Visitor Model
  - Enables or Disables Access Journey Trips & Day-Trip market segment
- Resident Model
  - Enables or Disables weekday only employment
  - Scales the HBW productions as necessary, alters the magnitude of HBW trips

Time-of-Day Pattern

- Visitor Model
  - Partitions the allocation of Access Journey Trips & At-Location Trips

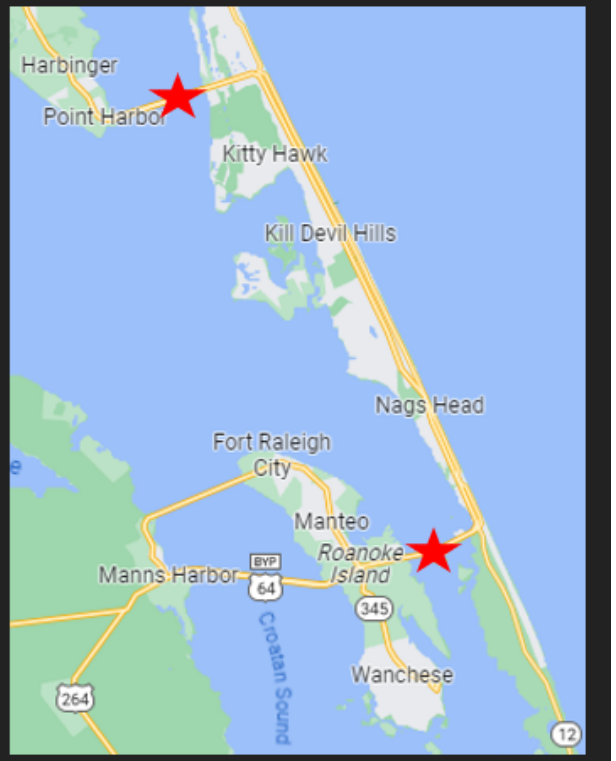
Barrier Island Bridge Intercept Concept

Multi-Condition Calibration

- AAWT – April Wednesday
- Peak Demand – July Saturday

Observed Volumes and Directional Patterns

- Combination of Resident and Visitor Trips
- Saturday includes:
  - Visitor Access Journey & At Location Trips
  - Resident Trips Modified by Month and Day Type
  - Impacts Trip Magnitude, Purpose & Time of Day Patterns



Counts vs. Volumes at Both Bridges

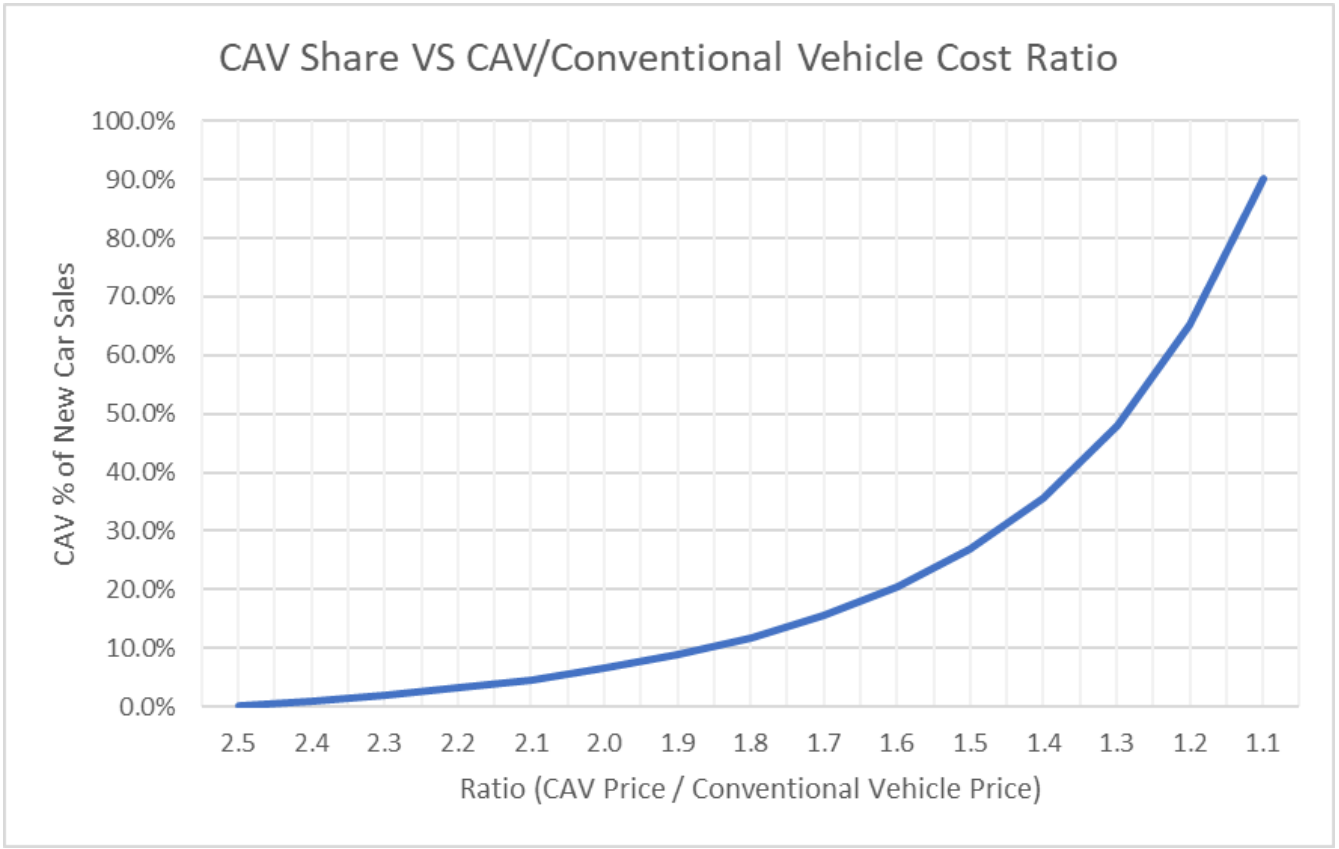
Time Period	Direction	April Wednesday				July Wednesday				July Saturday			
		Obs	Est	Diff	%Diff	Obs	Est	Diff	%Diff	Obs	Est	Diff	%Diff
AM (6 - 9 am)	EB	3,622	3,020	-602	-16.6%	4,061	4,421	360	8.9%	5,414	6,587	1,174	21.7%
	WB	2,571	1,741	-830	-32.3%	3,241	2,188	-1,052	-32.5%	7,613	7,243	-370	-4.9%
MD (9 am - 3 pm)	EB	7,452	8,489	1,037	13.9%	10,817	11,611	794	7.3%	16,329	17,618	1,289	7.9%
	WB	7,022	7,630	608	8.7%	10,680	10,084	-596	-5.6%	14,204	12,431	-1,773	-12.5%
PM (3 - 6 pm)	EB	4,161	3,152	-1,010	-24.3%	5,318	4,174	-1,144	-21.5%	8,607	8,174	-433	-5.0%
	WB	4,844	3,675	-1,170	-24.1%	6,052	5,126	-926	-15.3%	5,777	6,589	812	14.1%
Night (6 pm - 6 am)	EB	3,350	4,619	1,269	37.9%	5,417	6,704	1,287	23.8%	8,049	8,569	521	6.5%
	WB	3,566	6,070	2,504	70.2%	5,982	9,230	3,249	54.3%	9,235	12,793	3,559	38.5%
Day	EB	18,586	19,280	694	3.7%	25,612	26,910	1,298	5.1%	38,398	40,948	2,550	6.6%
	WB	18,003	19,115	1,113	6.2%	25,954	26,629	675	2.6%	36,828	39,056	2,228	6.0%
	2-way	36,589	38,395	1,806	4.9%	51,566	53,538	1,973	3.8%	75,226	80,004	4,778	6.4%

CAV Model Development

CAV Model Development

- **CAV Share Estimation of New Car Sales**
  - Specify 3 market share values and
  - Model generates predictive curve

CAV/Conventional Vehicle Cost Ratio	Assumed CAV Share of New Vehicle Sales	Estimated CAV Share of New Vehicle Sales
2.5	0.0%	0.1%
2.4		0.9%
2.3	1.8%	1.9%
2.2		3.1%
2.1		4.6%
2.0		6.5%
1.9		8.8%
1.8		11.7%
1.7		15.5%
1.6		20.4%
1.5		26.9%
1.4		35.8%
1.3		47.9%
1.2		65.1%
1.1	90.0%	90.2%



CAV Model Development

- **CAV Fleet Penetration Share Estimation by Horizon Years**

Year	Total Vehicles (1)	New Vehicles Sales				CAVs Phased Out (4)	Total CAVs	CAV Fleet Penetration
		Total (2)	CAV / Conventional Cost ratio (3)	CAV	Conventional			
2020	194,000,000	17,000,000	2.4	157,562	16,842,438	0.00	157,562	0.081%
2021	194,000,000	17,000,000	2.3	327,512	16,672,488	0	485,074	0.250%
2022	194,000,000	17,000,000	2.2	534,230	16,465,770	0	1,019,304	0.525%
2023	194,000,000	17,000,000	2.1	787,924	16,212,076	0	1,807,228	0.932%
2024	194,000,000	17,000,000	2.0	1,102,328	15,897,672	0	2,909,556	1.500%
2025	194,000,000	17,000,000	2.0	1,102,328	15,897,672	0	4,011,884	2.068%
2026	194,000,000	17,000,000	1.9	1,496,184	15,503,816	0	5,508,068	2.839%
2027	194,000,000	17,000,000	1.8	1,995,471	15,004,529	0	7,503,539	3.868%
2028	194,000,000	17,000,000	1.7	2,636,837	14,363,163	0	10,140,376	5.227%
2029	194,000,000	17,000,000	1.6	3,472,984	13,527,016	0	13,613,360	7.017%
2030	194,000,000	17,000,000	1.5	4,581,359	12,418,641	0	18,194,719	9.379%
2031	194,000,000	17,000,000	1.5	4,581,359	12,418,641	157,562	22,618,516	11.659%
2032	194,000,000	17,000,000	1.4	6,078,593	10,921,407	327,512	28,369,597	14.624%
2033	194,000,000	17,000,000	1.4	6,078,593	10,921,407	534,230	33,913,960	17.481%
2034	194,000,000	17,000,000	1.3	8,145,264	8,854,736	787,924	41,271,300	21.274%
2035	194,000,000	17,000,000	1.3	8,145,264	8,854,736	1,102,328	48,314,236	24.904%
2036	194,000,000	17,000,000	1.3	8,145,264	8,854,736	1,102,328	55,357,172	28.535%
2037	194,000,000	17,000,000	1.2	11,070,006	5,929,994	1,496,184	64,930,994	33.470%
2038	194,000,000	17,000,000	1.2	11,070,006	5,929,994	1,995,471	74,005,529	38.147%
2039	194,000,000	17,000,000	1.1	15,331,512	1,668,488	2,636,837	86,700,204	44.691%
2040	194,000,000	17,000,000	1.1	15,331,512	1,668,488	3,472,984	98,558,732	50.803%
2041	194,000,000	17,000,000	1.1	15,331,512	1,668,488	4,581,359	109,308,885	56.345%
2042	194,000,000	17,000,000	1.1	15,331,512	1,668,488	4,581,359	120,059,038	61.886%
2043	194,000,000	17,000,000	1.1	15,331,512	1,668,488	6,078,593	129,311,957	66.656%
2044	194,000,000	17,000,000	1.1	15,331,512	1,668,488	6,078,593	138,564,876	71.425%
2045	194,000,000	17,000,000	1.1	15,331,512	1,668,488	8,145,264	145,751,124	75.129%
2046	194,000,000	17,000,000	1.1	15,331,512	1,668,488	8,145,264	152,937,372	78.834%
2047	194,000,000	17,000,000	1.1	15,331,512	1,668,488	8,145,264	160,123,620	82.538%
2048	194,000,000	17,000,000	1.1	15,331,512	1,668,488	11,070,006	164,385,126	84.735%
2049	194,000,000	17,000,000	1.1	15,331,512	1,668,488	11,070,006	168,646,632	86.931%
2050	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%

Year	Total Vehicles (1)	New Vehicles Sales				CAVs Phased Out (4)	Total CAVs	CAV Fleet Penetration
		Total (2)	CAV / Conventional Cost ratio (3)	CAV	Conventional			
2020	194,000,000	17,000,000	2.4	157,562	16,842,438	0.00	157,562	0.081%
2021	194,000,000	17,000,000	2.3	327,512	16,672,488	0	485,074	0.250%
2022	194,000,000	17,000,000	2.1	787,924	16,212,076	0	1,272,998	0.656%
2023	194,000,000	17,000,000	2.0	1,102,328	15,897,672	0	2,375,326	1.224%
2024	194,000,000	17,000,000	1.9	1,496,184	15,503,816	0	3,871,510	1.996%
2025	194,000,000	17,000,000	1.8	1,995,471	15,004,529	0	5,866,981	3.024%
2026	194,000,000	17,000,000	1.6	3,472,984	13,527,016	0	9,339,965	4.814%
2027	194,000,000	17,000,000	1.5	4,581,359	12,418,641	0	13,921,324	7.176%
2028	194,000,000	17,000,000	1.4	6,078,593	10,921,407	0	19,999,917	10.309%
2029	194,000,000	17,000,000	1.2	11,070,006	5,929,994	0	31,069,923	16.015%
2030	194,000,000	17,000,000	1.1	15,331,512	1,668,488	0	46,401,435	23.918%
2031	194,000,000	17,000,000	1.1	15,331,512	1,668,488	157,562	61,575,385	31.740%
2032	194,000,000	17,000,000	1.1	15,331,512	1,668,488	327,512	76,579,385	39.474%
2033	194,000,000	17,000,000	1.1	15,331,512	1,668,488	787,924	91,122,973	46.971%
2034	194,000,000	17,000,000	1.1	15,331,512	1,668,488	1,102,328	105,352,157	54.305%
2035	194,000,000	17,000,000	1.1	15,331,512	1,668,488	1,496,184	119,187,485	61.437%
2036	194,000,000	17,000,000	1.1	15,331,512	1,668,488	1,995,471	132,523,526	68.311%
2037	194,000,000	17,000,000	1.1	15,331,512	1,668,488	3,472,984	144,382,054	74.424%
2038	194,000,000	17,000,000	1.1	15,331,512	1,668,488	4,581,359	155,132,207	79.965%
2039	194,000,000	17,000,000	1.1	15,331,512	1,668,488	6,078,593	164,385,126	84.735%
2040	194,000,000	17,000,000	1.1	15,331,512	1,668,488	11,070,006	168,646,632	86.931%
2041	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2042	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2043	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2044	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2045	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2046	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2047	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2048	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2049	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%
2050	194,000,000	17,000,000	1.1	15,331,512	1,668,488	15,331,512	168,646,632	86.931%

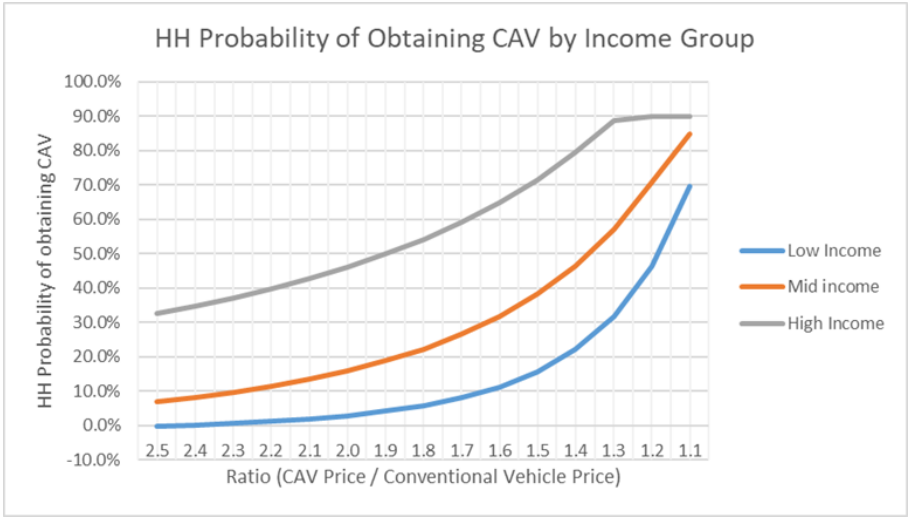
CAV Model Development

- **Key Features**
  - Trips generated by household type (conventional vehicle vs. CAV)
  - Trips estimated by trip purpose (HBW, HBSHOP, HBSCH, HBO, NHBW, NHBO)
  - Travel modes controlled by household type
  - Mobility service provider (MSP) mode – (driverless Uber, Lyft)
  - Generation of zero occupant trips

Household Type	Trip Purpose	Available Modes						Generates Zero Occupant Trips	
		Privately - Owned				Public			
		Conventional Vehicle		CAV					
		Drive Alone	Shared Ride	Drive Alone	Shared Ride	MSP CAV	Transit	Private CAVs	MSP CAVs
Conventional Vehicle HH (Exclusive)	Home-Based Work	*	*			*	*		Yes
	Home-Based Shop	*	*			*	*		Yes
	Home-Based School - Elem.	*	*				*		
	Home-Based School - Middle	*	*				*		
	Home-Based School - High	*	*			*	*		Yes
	Home-Based Other	*	*			*	*		Yes
	Non-home Based	*	*			*	*		Yes
CAV HH (Mixed ---> Exclusive)	Home-Based Work	*	*	*	*	*	*	Yes	Yes
	Home-Based Shop	*	*	*	*	*	*	Yes	Yes
	Home-Based School - Elem.	*	*	*	*		*		
	Home-Based School - Middle	*	*	*	*		*	Yes	
	Home-Based School - High	*	*	*	*	*	*	Yes	Yes
	Home-Based Other	*	*	*	*	*	*		
	Non-home Based	*	*	*	*	*	*	Yes	Yes

CAV Model Development

- **Household Allocation**
  - Allocation of CAV households by income groups
- **Trip Generation**
  - Assumption of trip rate adjustments (Tier1)
  - Allocation of increased trips into household types (Tier2)
- **Trip Distribution**
  - Assumption of trip distance increase by trip purposes



Life Cycle		Number of Workers		Income	
Category	Tier 2 Factor	Workers	Tier 2 Factor	Income Group	Tier 2 Factor
Seniors	1.00	0	1.00	low	1.00
Children	1.10	1	1.00	Mid	1.00
No Seniors & Childen	1.10	2	1.05	High	1.05
		3+	1.10		

Composite Tier 2 Factor Examples

Senior HHs with zero workers and low income - average(1.0,1.0,1.0) = 1.0

Children HHs with 2 workers and High Income - average(1.10,1.05,1.05) = 1.0667

CAV Model Development

- **Mode Choice Times and Costs**
  - Costs and times are different for MSP CAVs
  - Costs also include zero occupant trips

Trip Mode		Highway Impedances							Transit Impedances								
General	Specific Mode	In-vehicle Time	Wait Time[1]	Terminal Time[2]	Access Distance[3]	Parking Cost[4]	Toll Cost	Vehicle Operating Cost[5]	In-vehicle Time[6]	Walk Time[7]	Initial Wait (Short)	Initial Wait (Long)	Xfer Wait	Xfers	Vehicle Operating Costs[8]	Parking Cost[9]	Fare
Private Conventional Vehicle	Drive Alone	•		•		•	•	•									
	Shared Ride	•		•		•	•	•									
Private CAV	Drive Alone	•		•		•	•	•									
	Shared Ride	•		•		•	•	•									
MSP CAV	Ride Alone	•	•		•		•	•									
	Shared Ride	•	•		•		•	•									
Local Bus	Walk Access								•	•	•	•	•	•			•
	Drive Access								•	•	•	•	•	•	•	•	•
	CAV Access								•	•	•	•	•	•	•		•

Notes:

(1) - Time spent waiting for MSP CAV to arrive

(2) - MSP CAV have minimal terminal times that decline as CAV Fleet Penetration exceeds 60%

(3) - MSP CAV incur distance to travel to pickup passengers - influences vehicle operating costs

(4) - MSP CAV have no parking costs

(5) - MSP CAV operating costs include access distance-related costs, operator fees and taxes

(6) - Transit IVT are non-zero for valid transit paths. Auto access times included as part of IVT times

(7) - Transit walk time includes any access, egress and transfer walk times

(8) - includes private vehicle operating costs for auto access costs, CAV values multiplied by 2.0

(9) - Transit parking costs applicable only to privately owned vehicles. Transit parking costs are likely minimal in most regional planning districts

CAV Model Development

- **Zero Occupant Trips – Privately Owned CAVs**
  - **Processing Varies by Trip Purpose**
    - **HBW** – Percentage of zero occupant vehicle trips varies by time. (Added Trips)
      - Less than 10 minutes – 100% zero occupant return vehicle trips
      - Greater than 40 minutes – 0% zero occupant return vehicle trips
      - 10 – 40 minutes – Transitions between 100%→0%. User controls low time transition value
    - **HB Shopping Trips** - Assumes 75% of total shopping trips have parking idle vehicles. Assumes that all of these shopping trips will be zero occupant trips. (Replacement Trips)
    - **HB School Trips** – Assumes that 100% of privately-owned CAV trips for middle school and high generate zero occupant trips. (Added Trips)
    - **NHB Trips** – Calculated as a function of HB Shopping trip linked to another shopping destination. (Replacement trips subtracted from NHB purpose)
    - Transit Access – Assumes 100% of CAV trips generate zero occupant return vehicle trips. (Added Trips)

Questions?