Model Development & Applications at the Atlanta Regional Commission for Transportation Planning

Guy Rousseau, Atlanta Regional Commission

FDOT District 4 Southeast Florida FSUTMS Users Group Meeting

Friday September 14 2018
ARC Modeling & Planning Boundaries

*Gainesville-Hall MPO
**Cartersville-Bartow MPO
Designated Feb. 2013
ARC ABM Components

- ABM (CT-RAMP): internal person trips
- Externals: external/internal and external/external vehicle trips
- Trucks: commercial vehicle, medium duty truck, heavy duty truck trips
- Air Passenger: air passenger trips to/from Hartsfield-Jackson
ARC Modeling Evolution for Transportation Planning

ARC Trip-Based Model
- Household Cross-Tabulation
- Daily Household Trip Rates
  - Aggregate Zonal Trips

ARC Activity-Based Model
- Disaggregate Population
- Individual Choices
  - Individual Activity Patterns
ARC ABM True-Shape Display & Network Conflation

Snap nodes to shapefile nodes by turning on snap feature and dragging network nodes to shapefile nodes.
Network Coding Evolution: from a Trip-Based “Stick” Network to an ABM Conflated Network
Server Specs to Efficiently Run the ARC ABM

<table>
<thead>
<tr>
<th>Server</th>
<th>Physical Cores</th>
<th>Logical Cores</th>
<th>CPU</th>
<th>RAM</th>
<th>Harddrive Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main/Node 1</td>
<td>48</td>
<td>96</td>
<td>Intel Xeon E5-4657L v2 @ 2.40GHz</td>
<td>448 GB</td>
<td>1.6 TB</td>
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<tr>
<td>Node 2</td>
<td>48</td>
<td>96</td>
<td>Intel Xeon E5-4657L v2 @ 2.40GHz</td>
<td>192 GB</td>
<td>1 TB</td>
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## Atlanta’s Activity-Based Model (ABM) Person Types

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>PERSON-TYPE</th>
<th>AGE</th>
<th>WORK STATUS</th>
<th>SCHOOL STATUS</th>
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<tbody>
<tr>
<td>1</td>
<td>Full-time worker</td>
<td>18+</td>
<td>Full-time</td>
<td>None</td>
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<tr>
<td>2</td>
<td>Part-time worker</td>
<td>18+</td>
<td>Part-time</td>
<td>None</td>
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<tr>
<td>3</td>
<td>Non-working adult</td>
<td>18 – 64</td>
<td>Unemployed</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>Non-working senior</td>
<td>65+</td>
<td>Unemployed</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>College student</td>
<td>18+</td>
<td>Any</td>
<td>College +</td>
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<tr>
<td>6</td>
<td>Driving age student</td>
<td>16-17</td>
<td>Any</td>
<td>Pre-college</td>
</tr>
<tr>
<td>7</td>
<td>Non-driving student</td>
<td>6 – 16</td>
<td>None</td>
<td>Pre-college</td>
</tr>
<tr>
<td>8</td>
<td>Pre-school</td>
<td>0-5</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
## Atlanta’s Activity-Based Model (ABM) Activity Types

<table>
<thead>
<tr>
<th>TYPE</th>
<th>PURPOSE</th>
<th>DESCRIPTION</th>
<th>CLASSIFICATION</th>
<th>ELIGIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Work</td>
<td>Working at regular workplace or work-related activities outside the home.</td>
<td>Mandatory</td>
<td>Workers and students</td>
</tr>
<tr>
<td>2</td>
<td>University</td>
<td>College +</td>
<td>Mandatory</td>
<td>Age 18+</td>
</tr>
<tr>
<td>3</td>
<td>High School</td>
<td>Grades 9-12</td>
<td>Mandatory</td>
<td>Age 14-17</td>
</tr>
<tr>
<td>4</td>
<td>Grade School</td>
<td>Grades K-8</td>
<td>Mandatory</td>
<td>Age 5-13</td>
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<tr>
<td>5</td>
<td>Escorting</td>
<td>Pick-up/drop-off passengers (auto trips only).</td>
<td>Maintenance</td>
<td>Age 16+</td>
</tr>
<tr>
<td>6</td>
<td>Shopping</td>
<td>Shopping away from home.</td>
<td>Maintenance</td>
<td>5+ (if joint travel, all persons)</td>
</tr>
<tr>
<td>7</td>
<td>Other Maintenance</td>
<td>Personal business/services, and medical appointments.</td>
<td>Maintenance</td>
<td>5+ (if joint travel, all persons)</td>
</tr>
<tr>
<td>8</td>
<td>Social/Recreational</td>
<td>Recreation, visiting friends/family.</td>
<td>Discretionary</td>
<td>5+ (if joint travel, all persons)</td>
</tr>
<tr>
<td>9</td>
<td>Eat Out</td>
<td>Eating outside of home.</td>
<td>Discretionary</td>
<td>5+ (if joint travel, all persons)</td>
</tr>
<tr>
<td>10</td>
<td>Other Discretionary</td>
<td>Volunteer work, religious activities.</td>
<td>Discretionary</td>
<td>5+ (if joint travel, all persons)</td>
</tr>
</tbody>
</table>
### Atlanta’s Activity-Based Model (ABM) Time of Day Periods

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>DESCRIPTION</th>
<th>BEGIN TIME</th>
<th>END TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Early</td>
<td>3:00 A.M.</td>
<td>5:59 A.M.</td>
</tr>
<tr>
<td>2</td>
<td>A.M. Peak</td>
<td>6:00 A.M.</td>
<td>9:59 A.M.</td>
</tr>
<tr>
<td>3</td>
<td>Midday</td>
<td>10:00 A.M.</td>
<td>2:59 P.M.</td>
</tr>
<tr>
<td>4</td>
<td>P.M. Peak</td>
<td>3:00 P.M.</td>
<td>6:59 P.M.</td>
</tr>
<tr>
<td>5</td>
<td>Evening</td>
<td>7:00 P.M.</td>
<td>2:59 A.M.</td>
</tr>
</tbody>
</table>
Atlanta’s Treatment of Transport Modes

- Explicit Toll versus Non-Toll Choice in Mode Split
- School Bus is a Trip Mode for Traffic Assignment
Atlanta’s Single-Occupant Vehicles Origin-Destination Desire Lines
Atlanta’s Traffic Assignment Animation via Transims Router
Atlanta’s Integrated Transport/Land Use Model

• 2 Types of Linkages:
  • **Connection**: Feeding Land-Use Model Estimates of Population and Employment to ABM
  • **Integration**: Leveraging Labor Flows from Spatial Input-Output Model (PECAS) to Determine Workplace Location Choice
Atlanta’s Integrated Transport/Land Use Model

Workplace Location Choice Example

Mode Choice Logsum Matrix* (alpha zone)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.06</td>
<td>0.34</td>
<td>0.35</td>
<td>0.19</td>
<td>0.01</td>
<td>0.04</td>
</tr>
<tr>
<td>2</td>
<td>0.09</td>
<td>0.17</td>
<td>0.03</td>
<td>0.08</td>
<td>0.34</td>
<td>0.30</td>
</tr>
<tr>
<td>3</td>
<td>0.07</td>
<td>0.21</td>
<td>0.16</td>
<td>0.21</td>
<td>0.14</td>
<td>0.20</td>
</tr>
<tr>
<td>4</td>
<td>0.11</td>
<td>0.14</td>
<td>0.22</td>
<td>0.21</td>
<td>0.25</td>
<td>0.07</td>
</tr>
<tr>
<td>5</td>
<td>0.17</td>
<td>0.07</td>
<td>0.02</td>
<td>0.31</td>
<td>0.18</td>
<td>0.27</td>
</tr>
<tr>
<td>6</td>
<td>0.20</td>
<td>0.19</td>
<td>0.21</td>
<td>0.20</td>
<td>0.14</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*The Mode Choice Logsum matrix take into account the time and cost of travel by all modes of transportation, according to traveler perceptions about the importance of the attributes of each mode, as well as non-included attributes that affect the probability of taking each mode between each origin-destination pair.

Labor Flow Matrix (beta zone)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1.5M Labor Flow</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$0.25M Intrazonal</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>$0.25M Intrazonal</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

$ Production (alpha)

$ Consumption (alpha)
Land Use Model (PECAS) to Activity-Based Model (ABM) Integration:

• On the Land Use Side:
  • ABM Takes Employment Projections from PECAS as Part of its Inputs
  • Returns Accessibility Measures to PECAS once it Forecasts Travel Demand
Goals of Land Use Model (PECAS) to Activity-Based Model (ABM) Integration:

• Small Area (TAZ) Land Use Estimates for Use in Destination Choice Models
  • Employment for 20 Industrial Classifications
  • Total Households

• Synthetic Population Control Totals
  • Household by Size and Income (TAZ Control)
  • Workers by Occupation (LUZ Control)
Reality of Land Use Model (PECAS) to Activity-Based Model (ABM) Integration:

• PECAS Small Area Forecasts may be Adjusted due to:
  • Consultation with Local Jurisdictions
  • Forecast Overrides to Correct for Incomplete Base Year Parcel Data
Activity-Based Model (ABM) to Land Use Model (PECAS) Integration:

• LUZ (Land Use Zone) to LUZ Accessibilities:
  • Work Location Mode Choice Logsums
  • Impedances (Travel Times, Distances, Tolls)
Model Applications and Corridor Analysis Data Tools with INRIX & Data

• Comparative travel speed: measured as a percentage of average speed for that day/time

• Using 2015 INRIX Data

• Freeway Corridors (Interstate and State Routes)

• Regionally Significant Corridors (Arterials)
Corridor: I-285 (top end)

• The **blue line** in the chart shows **comparative speed**, which is the speed of traffic for that time measured as a percentage of historic average speed for that day/time.

• For example, if “normal” traffic speed is 40mph, 100% would represent 40 mph and 50% would represent 20 mph.

• The **red area** on the chart highlights where speed has dropped **below 80 percent** of historic average speed.
Corridor: Lenox Rd

- The **blue line** in the chart shows **comparative speed**, which is the speed of traffic for that time measured as a percentage of historic average speed for that day/time.
- For example, if “normal” traffic speed is 40mph, 100% would represent 40 mph and 50% would represent 20 mph.
- The **red area** on the chart highlights where speed has dropped **below 80 percent** of historic average speed.
March 30 2017
I-85 Bridge Collapse Travel Patterns Analysis with Streetlytics Data
I-85 Bridge Collapse

- **March 30 2017**: Fire underneath I-85 NB caused the bridge to collapse and altered the commutes for hundreds of thousands of commuters.

- Around **250,000** trips go through the impacted area each weekday.

- Eastern half of the I-285 perimeter impacted the most, but travel was impacted all throughout the region, with a minimum of **30%** increase in volumes across network.

- Many MARTA stations, especially those in the northern part of the region, have experienced large *increases* in ridership after the bridge collapse.

- **75%** of the businesses in the area have experienced a loss of customers due to the collapse.

- **Bridge reopened on May 15, 6 weeks later** ...
Who travels on I-85?

http://arcg.is/OLC1mW

• The affected area on I-85 is a critical link in the transportation network

• In the morning travel period, trips routinely flow from as far south as Newnan and from as far north as Cumming (Data source: Streetlytics)
Externals Model Update with Airsage Data

• Work is currently underway
• Airsage Data Processing & External Model Update Methodology
  • Define Zone Structure
  • Create Equivalencies between External Stations and External County Zones (multiple stations will fall within an external county zone)
  • Comparison of OD Trips to Traffic Counts as Validation of Data Integrity
  • Factor External OD Trips to Match Traffic Counts & Verify Travel Patterns
  • Data Disaggregation by Time Period, then Convert from OD to PA Format
  • Assign Disaggregated OD Trips to Highway Network and Perform Additional Validation of Data Integrity
  • Trip Generation & Compute Accessibility Terms to External Stations
  • Trip Distribution & Prepare Average Trip Length Targets & Frequency Curves for Calibration, then Calibrate Friction Factors to Match Observed Trip Lengths & Frequency Curves
I-285 @ GA-400 Interchange Reconstruction Commute Options with Streetlight Data

• Goal: Better Understand Travel Behavior Using Origins and Destinations with Select Links for Different Employment Centers
  • Trip Duration & TLFD
  • Commercial Trips & Personal Trips
  • Provide Alternative Commute Options to Travelers Affected by Interchange Reconstruction
Regional Origin-Destination Analysis with Teralytics Data (Work NOT yet Underway)
VDF Volume-Delay-Reliability Functions (SHRP2 L04) with NPMRDS Data

• Roadway link-level reliability measures were estimated to establish VDRF functions to replace the standard VDFs in highway assignment.

• Functions fully segmented by link function class types
  • Freeways
  • Arterials
  • Collectors/locals
  • Ramps

• Standard Deviation (SD) of travel time per mile is the explored dependent variable.

• The main independent (explanatory) variable was Congestion Index (CI) which is a ratio of average travel time to free-flow time.
AM Peak Google-Based Travel Times to Atlanta CBD (for 3 different days)
AM Peak Travel Times to Atlanta CBD
## ARC ABM Sensitivity Testing

<table>
<thead>
<tr>
<th>Grouping</th>
<th>No.</th>
<th>Description</th>
<th>Incorporation</th>
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<tbody>
<tr>
<td>Highway Capacity</td>
<td>1</td>
<td>1/2 base capacity</td>
<td>Cube script</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Base capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2x base capacity</td>
<td></td>
</tr>
<tr>
<td>Transit Fare</td>
<td>4</td>
<td>No fare</td>
<td>UEC</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1/2 base fare</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Base fare</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>2x base fare</td>
<td></td>
</tr>
<tr>
<td>Fuel Cost</td>
<td>8</td>
<td>1/2 base fuel cost</td>
<td>UEC / Cube script</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Base fuel cost</td>
<td></td>
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<tr>
<td></td>
<td>10</td>
<td>2x base fuel cost</td>
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<tr>
<td>Transit IVTT</td>
<td>11</td>
<td>95% base transit IVTT</td>
<td>UEC</td>
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<td></td>
<td>12</td>
<td>Base transit IVTT</td>
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<tr>
<td></td>
<td>13</td>
<td>105% base transit IVTT</td>
<td></td>
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</tbody>
</table>
Trip Table Convergence Check

Percent RMSE Comparison by OD Trip Ranges

Correlation Coefficient Comparison by OD Trip Ranges

Total Trips by OD Trip Range

Average Trips by OD Trip Range
Minimizing Sources of Risk & Uncertainty in ABM

- Some error propagation in a fully integrated transport/land use model:
  - Land use components & uncertainty in demographic inputs / socioeconomic projections
  - Outputs from land use model act as inputs into travel demand model
  - Uncertainty in various model parameters
  - Cumulative effects send shockwaves through an integrated model
Possible Sources of Data Uncertainty in ABM

Model Calibration
- Relative Imprecision
- Systematic Biases

Estimation of Parameters
- Small Travel Survey Sample Sizes
- Non-Representative Travel Survey Samples
Other Sources of Risk & Uncertainty in ABM

- Monte Carlo random draws in synthetic population
  - Random sampling from inputs distribution
  - Requires large number of samples (PUMS, PUMAS, etc.)
  - Need to allow representation of extremes in probability distribution of outputs
Estimate Uncertainty in Congestion Benefits of Capacity-Adding Projects

• For Road Projects:
  • Differences in observed vs. modeled VMT for certain functional classes
  • % error between observed counts and model estimated counts
  • RMSE should decrease as traffic volumes increase
Scenario Modeling for Planning: Increase Propensity to Use Transit

Adjust transit constants – less auto trips
For specific access modes, purposes, market segments, origins/destinations, etc.
• Adjust non-motorized constants in ARC’s ABM UECs
• Increased density & land use mix have positive effects on walk & bike
## Scenario Modeling for Transportation Planning: Managed Lanes & Value Pricing

<table>
<thead>
<tr>
<th>Prohibition</th>
<th>SOV</th>
<th>HOV-2</th>
<th>HOV-3+</th>
<th>Trucks</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
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<td>✗</td>
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<tr>
<td>3</td>
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<tr>
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<td>13</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- No Trucks
- HOV 2+
- Managed Lanes - SOV Toll - HOV 2+ Free - No Trucks
- Truck Only Lanes
- I-285 Bypass
- HOV 3+
- Managed Lanes - SOV & HOV2 Toll - HOV 3+ Free - No Trucks
- Managed Lanes - SOV & Truck Toll - HOV 2+ Free
- Managed Lanes - SOV, HOV2 and Truck Toll - HOV 3+ Free
- Truck Only Toll
- Managed Lanes - HOV2 Toll - HOV 3+ Free - No Trucks or SOV
- Managed Lanes - SOV and HOV2+ Toll - No Trucks
- Managed Lanes – SOV, HOV2+ and Trucks Toll
Toll Optimization with Static Traffic Assignment

• Facilities with variable pricing require optimizing to ensure consistent results with CT-RAMP and the highway assignment

• Why? Toll/non-toll is part of both mode choice (CT-RAMP) and route choice (highway assignment)

• Optimization occurs in outer (CT-RAMP and other models) and inner (assignment) loops

• Optimization approach seeks to modify the tolls until the generalized cost of the toll lanes and general-purpose lanes are equal for a specific section
Air Passenger Model

Step One: Estimating Total Airport Passengers
- Annual Enplanements
- Transferring Passengers and Conversion to Daily Passengers
- Split into Trip Purposes

Step Two: Trip End Allocation
- Residents
  - Private Auto
  - Non-Private Auto
    - Drive Self
    - Transit
    - Taxi
- Non-residents
  - Dropped Off
  - Rental Car
  - Non-Private Auto
    - Transit
    - Taxi
Model Applications for Transportation Planning: Autonomous Vehicles Scenario Testing

- Limited to “What-if” scenarios
- Restricted to select factors, while assuming others constant
- Fuel Efficiency based on trends in CAFE standards and annual energy outlook by U.S. Dept. of Energy
- CAFE standards: 54.5 mpg in model year 2025, extrapolated to 2040 for light and heavy duty vehicles
- Additional fuel economy due to efficient operation of autonomous vehicle, resulting in a reduction in overall vehicle operating cost
C/AV Planning Assumptions for Modeling

• **Perceived travel time disutility**
  • Less onerous in-vehicle travel time
  • In-vehicle productivity: Reduced disutility
  • Affects tour.trip mode choice utilities

• **Parking cost**
  • Driverless cars significantly reduce the need for paid parking
    • Work and non-work trips

• **Increased Roadway Capacity**

• **NHTSA Level 4 - 100% market penetration in 2040**
C/AV Modeling Methodology

- Tour and Trip Mode Choice Utility Expression Calculators (UECs)
  - **AV_Perc_Factor**: Reduce In-Vehicle Travel Time (IVTT) coefficients for autos by 50%
  - Increase fuel efficiency in operating cost
    - 70% reduction in vehicle operating cost from present
  - Parking costs at primary destinations set to zero

- Generalized cost in highway assignment
  - Reduce auto and truck operating costs

- Increase roadway capacity by 50%

- 0-Car Households have access to Single-Occupant Vehicles with Autonomous Vehicles scenario
C/AV Modeling Scenarios

• Incremental Approach

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2040 NB</th>
<th>C</th>
<th>CT</th>
<th>CTO</th>
<th>CTOP</th>
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<tbody>
<tr>
<td>baseline</td>
<td></td>
<td>• capacity increase</td>
<td>• capacity increase</td>
<td>• capacity increase</td>
<td>• capacity increase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• decrease in travel time disutility</td>
<td>• decrease in travel time disutility</td>
<td>• decrease in travel time disutility</td>
<td>• decrease in travel time disutility</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• reduction in vehicle operating cost</td>
<td>• reduction in vehicle operating cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• reduction in parking cost</td>
</tr>
</tbody>
</table>
C/AV Model Results

Total Trips and Average Trip Length

- **Daily Vehicle Trips**
- **Avg. Trip Length**

**Scenarios:**
- **Base**
- **C**
- **CT**
- **CTO**
- **CTOP**

**Graph Details:**
- Y-axis: Total Daily Trips (Millions)
- X-axis: Average Trip Length (Miles)
- **Base**
  - 21.0
- **C**
  - 21.2
- **CT**
  - 21.4
- **CTO**
  - 21.6
- **CTOP**
  - 21.8

**Percentage Changes:**
- **C** to **Base**: 0.8%
- **CT** to **Base**: 2.0%
- **CTO** to **Base**: 2.5%
- **CTOP** to **Base**: 2.6%
C/AV Model Results

VMT and VHT Changes by Scenario

- Daily VMT
- Daily VHT
C/AV Model Results

Transit Trips by Scenario

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Daily Transit Trips</th>
<th>Regional Transit Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>400,000</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>397,900 (-1.1%)</td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td>377,200 (-25.8%)</td>
<td></td>
</tr>
<tr>
<td>CTO</td>
<td>247,200 (-38.3%)</td>
<td></td>
</tr>
<tr>
<td>CTOP</td>
<td>160,300 (-42.4%)</td>
<td></td>
</tr>
</tbody>
</table>
ABM Lessons Learned at ARC

• ABM Requires Detailed & Thorough QA/QC

• Design & Conceptualize your Household Travel Survey with an ABM Model System in Mind

• Need to Visualize ABM Results: http://atlregional.github.io/ABMVIZ/

• Like Anything Else, ABM Requires *Lots* of:

  – Dedicated Staff Resources & On-Going Training
  – DATA (Travel Surveys and/or “AirSage” O-D types)
  – Computer Resources (Servers or Cloud Computing?)
  – Consultants Assistance
  – Programming Expertise (Java, Python, R, Stata, etc.)
  – GIS & a True Geo-Database for Enhanced Network Coding and Project-Level Planning
  – $,$$,$$$.$$$
Atlanta’s Most Crucial Step:  
Moving ARC’s ABM into Practice & Official Production Mode for Regional Transportation Planning

• Thus far ABMs are being Developed and Applied mostly in Regions where 4-step Models had been Abandoned or never Developed

• Rigorous Practical Testing and Cross-Comparisons of ABM & 4-Step Trip-Based Model (both in good shape!) is Finally Possible in Atlanta
Thanks!

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