PECAS
Production Exchange Consumption Allocation System
Modeling Review and Update

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ATLANTA REGION PLAN 2040

ARC Atlanta Regional Commission
Q1: What (land use) model are COGs/MPOs already implementing?

- ARC is in process of implementing a PECAS model (HBA Specto) for small-area forecast allocation of control totals derived from a REMI model (with Technical Advisory Group input).
- PECAS will replace the DRAM/EMPAL model used since the early 1990s. A custom product developed in tandem with PB, called the TAZ-Disaggregator (TAZ-D) is being used as a “bridge model” while PECAS is under development.
Q2, 5: What stage of implementation is the ARC? How is PECAS to be used?

- PECAS has two modules: Activity Allocation (AA) and Spatial Development (SD). We have run both modules, integrated and for 20-counties (thus full model) uncalibrated through time for a three year test period of 2005-2008. Current status is 2nd and 3rd stage calibration of both modules, and base data refinement.

- The goal for development is, by end of 2010, an integrated run through plan horizon year of 2040, with calibration of parameters nearing completion, and best available base data in place.

- Our modeling goal is to use PECAS as small-area allocation model in conformity work for next RTP/RDP (est. 2014-15 delivery date), as well as more ongoing scenario work and TIP modeling.
Q3,4,6: What are the major issues of implementation and how they are being overcome?

- Data demands - **parcel polygons, zoning information**, cost data, equation parameters
  - Building relationships (involving education) to collect the data from constituents
  - Close cooperation of other internal divisions (Land Use, Transportation) in building impedance and zoning information
  - Collaborative post-processing of in-house or public sector data (Estimates, Census Data)
  - Purchase of data from third-parties in private sector (Means, Epermits, IMPLAN)
- Module calibration
  - Automated procedures developed or being developed by consultants
- Output analysis (to inform calibration)
  - Custom spreadsheets and charting
  - CSV Data Loader
  - Web Mapping and Analysis Interface
### County Parcel Data

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<tr>
<th>County</th>
<th>Parcels</th>
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<td>Walton</td>
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<td><strong>Total</strong></td>
<td><strong>1,934,417</strong></td>
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- **20-County parcel features**

We tried to print it, but the machine kept crashing....
So which table has the year a structure was built???
Zoning Clean-up Will It Ever End??

UHHHH....... NO
## AA—Transportation Cost Coefficients

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<th>Skim Name</th>
<th>Skim Units</th>
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AA-Price Estimations

Landlord function - "Think Like a Landlord"

Very few of the observed prices should be at very low vacancy rates, perhaps one or two observed prices could be below the lowest observed vacancy rate, but no more than one or two. These are extreme situations that rarely occur in reality.

Curve crosses the y axis above zero - 100% vacancy occurs at a positive price.

Highest observed price should be close to 100% Occupancy

Most observed rents should correspond to typical vacancy rates

Corner should not be too sharp, reduce eta to as low as possible while still meeting the other requirements.
AA-Trip Length Calibration

Commodity Buying Selling Group
CG01AgMinDirection selling Work-Other
CG02AgMinOutput buying CV Heavy
CG03ConDirection selling Work-Other
CG04ConOutput buying CV Heavy
CG05MfgDirection selling Work-Other
CG06MfgOutput buying CV Med/Light
CS07TCUDirection selling Work-Other
CS08TCUOutput buying CV Med/Light
CS10RetailOutput buying HB Shop
CS11FIREOutput buying Work-Other
CS13OthServOutput buying HB Other
CS14HealthOutput buying HB Other
CS15GSEDOutput buying HB School
CS16HiEDOutput buying HB Univ
CS17GovOutput buying Work-Other
CL23WhiteCollar selling HB Work
CL24Services selling HB Work
CL25Health selling HB Work
CL26Retail selling HB Work
CL27BlueCollar selling HB Work
CL28Military selling HB Work

```python
import csv
import os
import chutil
import time

# GLOBAL CONSTANTS

define the files to access; these are/vill be standard.
targetFileName = "TLCtargets1.csv"  # name of target file
groupFileName = "TLCgroups1.csv"  # name of group definition file
histoFileName = "histograms.csv"  # histogram file created by IA
commodityFile = "commodities1.csv"  # commodities file from AA

outFileName = "TLCCalib.csv"  # output file name
modelCommand = "/RunAA.sh"  # the file that runs A1

filesToVersion = ["event.log", "histograms.csv"]  # copy all files in this list a
upperClip = 2.2  # the maximum increase in param. value between iterations
lowerClip = 0.5  # the minimum increase in param. value between iterations
maxIts = 10  # maximum number of iterations to run
gapRange = 0.05  # stop calibration when all errors are +/- this value
initScale = 1.2  # initial scale factor; adjust parameters by this for second run

# This program works on a paramList, which is a list of groups, structured
# as follows:
# ["name", target, curr param, curr result, last param, last result]
# where:
# 0: "name" is the group name (e.g. heavy commercial vehicles)
# 1: target is the trip length target, taken from whatever skim is used in H1
# 2: curr param is the parameter for the current / most recent model run
# 3: curr result is the average trip length from the most recent model run
# 4: last param is the parameter from the previous run
# 5: last result is the average trip length from the previous run
```

A| B | C   |
---|----|-----|
1  | Group| Target| Param  |
2  | CV Heavy| 45    | 5.00E+00 |
3  | CV Med/L| 35    | 5.00E+00 |
4  | HB Other| 17.5  | 1.00E-01 |
5  | HB School| 15.48 | 1.00E-01 |
6  | HB Univ| 28.95 | 1.00E-01 |
7  | HB Work| 16.4  | 1.00E-01 |
8  | Work-Oth| 34    | 5.00E+00 |
9  |       | 18    | 1.00E-01 |
10 |       |       |        |
### Local effect coefficients

- **Fulton County**
- Institutional spaces
- Last sold price

#### exponential

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<th>I ($r^2=0.195$)</th>
<th>INS ($r^2=0.199$)</th>
<th>O ($r^2=0.155$)</th>
<th>R ($r^2=0.153$)</th>
<th>RD ($r^2=0.194$)</th>
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<td>0.33</td>
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</tbody>
</table>

### Notes
- Values in parentheses indicate standard errors.
- Ratio values are given in parentheses for each term.
- SD: Rents
SD: New SD Database

- Migrated SD databases to PostgreSQL
- New database schema
- 20-County SD database are loaded
  - 2 million records in the parcel table
  - 10 million records in the local effect table
  - More pseudo parcels
  - AND these numbers are for one year of data....
Building a query for ExchangeResults.csv

List of attributes in the file: price
Aggregate function: Sum() ○ Average() ○ Count()
Scenario: W00
Start year: 2005 - End year: 2010
Commodity/Commodity Group: CA35DetResid

Create DB view

- View "W00_CA35DetResid_108714_113609" was successfully created!
- View "W00_CA35DetResid_108714_113609_wb_geem" was successfully created!

Show map!
SQL Table Views for Output instead of .CSVs
Open Source GIS link
Where It Has Taken Us...Today

– An integrated model run through time, with scenario evaluation
  • AA > SD > AA, 2005 through 2006
  • A scenario of increased transportation costs
  • AA running Region wide, but physical development only in Fulton County
    – Maps of results to follow
  • Sets the stage for further calibration (Stage 3)
– Capability for Full 20-county Run
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs

From Years 2005 To 2006

All Households Change

-467 - -211
-210 - -93
-92 - 0
1 - 51
52 - 150
151 - 338
339 - 726

Shapes based on 2000 Census tract boundaries. Data for 2000, 2005, and 2006 was acquired from the American Community Survey (ACS) and the 2000 Census. Data for 2040 was acquired from the Sustained Yield Model (SYM) and the Metropolitan Planning Model (MPM). Data for 2050 was acquired from the Sustainable Mobility Model (SMM) and the Regional Model (RM).
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

Less than 20K HH Income Household Change
-414
-413 - 0
1 - 13
14 - 101
102 - 246

0 2 4 8 Miles

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Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

Greater than 100K Income Household Change
-504 - -225
-224 - 0
1 - 78
79 - 375
376 - 1006
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

DEMAND CHANGE (SPACE)

Exchange Results
CA32Office

-217,647 - -151,671
-151,670 - -69,907
-69,906 - 0
1 - 87,542
87,543 - 559,429
559,430 - 1,021,390
1,021,391 - 2,410,720

02.55 10 Miles

Atlanta Regional Commission
Comparison Labor Types by Travel Distance

White Collar

Blue Collar

Total Value of Labor

Travel Distance in Miles

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

Double Tr Cost  No Increase

Double Tr Cost  No Increase
Scenario Tests-SD Results
Forecast Area (Superdistricts = building blocks)
The LU Allocation Model (PECAS)

- PECAS (Production, Exchange and Consumption Allocation System)
  - Developed by Drs Doug Hunt and John Abraham of University of Calgary
  - Based on sound economic theory, incorporating I-O modeling approach; achieves equilibrium
  - Two Modules, run Sequentially and Annually –
    - Activity Allocation (AA) Module: equilibrium exchange and consumption prices are established by larger zone (LUZ)
    - Space Development (SD) Module: based on pricing (rents) from AA and development costs, rational “developer” makes decision or non-decision to develop space in given smaller zones (TAZ) until the market ‘clears’

- Work Reviewed by the REMI/PECAS Technical Advisory Group (TAG)
PECAS:
Activity Allocation (AA)
Producing Sectors

Consuming Sectors

Goods, Services, Labour and Space

Economic Flows
Activity Allocation (AA)
joint discrete utility

\[ U^a_{lpe\epsilon_2\ldots\epsilon_n} = V_l^a + \epsilon_l^a + V_p + \epsilon_{lp} + \sum_{n=1}^{N_p} \alpha_{pn} s_{pn} \left( V_{e_{nl}} + \epsilon_{e_{nl}p} \right) \]

- **Additional utility associated with location \( l \) for activity \( a \)**
- **Additional utility associated with production option \( p \)**
- **Stochastic error terms**
- **Utility of exchanging and shipping one unit of Commodity between \( l \) and \( e \)**
- **Quantity of commodity produced or consumed under production option \( p \)**
PECAS:

Space Development (SD)
Space Development: Simulation of Transitions

parcel-by-parcel microsimulation

zoning dictates set of alternatives
Rent less amortized construction cost per unit space

Additional Rent less development costs per unit land

\[ RU_{hjp} = T_{hjp} j + lTr_{hjp} + l\varepsilon_s + l\varepsilon_q \]

Space quantity (building size)

Land quantity (parcel size)

Stochastic error terms
Nested logit structure

New space type

Add space

No change
Demolish
Derelict

Quantity

multi-level nested
discrete-continuous
logit
Design Diagram-Atlanta (Sorry about size)

Figure 1: Diagram Summarizing the Structure of the Atlanta PECAS Model
Generalized Development Process

• Gather behavioral data
• Establish targets
• 3-stage calibration
• Agile development
PECAS General Task List

task 1 SD Development
01: Establish parcel-level space rent equations
02: Establish space transition costs calculation system
03: Establish space maintenance costs equations
04: Establish base-year parcel database
05: Establish base-year quantities of space by type in each zone
06: Establish all-year parcel-level inputs for calibration period
07: Identify space transition constants

task 2 Transport Utility Equation Establishment
08: Establish transport utility equations

task 3 Technology Option Point Development
09: Identify household technology option points:
10: Identify industrial technology option points:
11: Identify accounts categories technology option points:

task 4 AA Target Development
12: Develop labor production zonal-level targets:
13: Develop labor consumption zonal-level targets:
14: Develop labor spatial flow targets:
15: Develop commodity production zonal-level targets:
16: Develop commodity consumption zonal-level targets:
17: Develop commodity spatial flow targets:
18: Develop import and exports targets:

task 5 Import Export Calibration
19: Establish imports and exports functions equation parameters:

task 6 AA Inputs Development
20: Develop skim matrices from transport model:
21: Develop X-Vector Attribute values

task 7 Stage 2 Calibration
22: Establish buying and selling utility equation parameters
23: Establish size terms for imports and exports in external zones
24: Establish technology allocation utility equation parameters
25: Establish location allocation utility equation sensitivity parameters
26: Establish location allocation utility equation zonal constants

task 8 Stage 3 Calibration
27: Set-up semi-automated calibration process
2008 Progress: AA Summary

- IMPLAN data = core of input data, along with PUMS and baseline employment data (NAICS)
- Initial integration with transport model achieved (skims)
- Unconstrained module (20-co) run in June ‘08, LUZ level
- Initial constrained module run in December 2008
PUMS Data: Occ by Industry

Education | Gvmt/Military | Industrial/Manuf. | Medical | Natl resource | Office/Prof. | Retail

- Retail
- Blue Collar
- White Collar
# Travel Demand Model Skims

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</tbody>
</table>

Cells with highlighted background indicate selected data.
2008 Progress: SD Summary

- Parcel spatial data and assessor data = core of input data
- Module (Fulton County) run in May 08, parcel level, with zoning
- Inconsistency between three data sources (assessor space, NAICS employment, LandPro acreage) reevaluation
- Used LandPro and NAICS employment to develop TAZ level targets for space (key: consistency across 20 counties)
- Then, disaggregated to parcel using Abraham Floorspace Synthesizer
- Initial synthesizer runs for 15 of the 20 counties
2009 Progress

- Focus of work: June-December 2009
- Model Integration
  - AA>SD>AA RUN through time
  - Transportation Model Output Incorporated and Used.
- Data Development
- Database Development
- 2nd stage Calibration (size terms, dispersion parameters, transition constants)
- Continued Consultant & Client Collaboration
  - Gotomeetings semi-weekly
  - Three workshops (March, September, November 2009)
  - Gotomypc logins
    - Allow for maintenance of Directory Structure
    - Facilitate coding
Commodity | Buying/Selling | Group
--- | --- | ---
CG01AgMinDirection | selling | Work-Other
CG02AgMinOutput | buying | CV Heavy
CG03ConDirection | selling | Work-Other
CG04ConOutput | buying | CV Heavy
CG05MfgDirection | selling | Work-Other
CG06MfgOutput | buying | CV Med/Light
CS07TCUDirection | selling | Work-Other
CS08TCUOutput | buying | CV Med/Light
CS09WsOutput | buying | CV Med/Light
CS10RetailOutput | buying | HB Shop
CS11FIREOutput | buying | Work-Other
CS13OthServOutput | buying | HB Other
CS14HealthOutput | buying | HB Other
CS15GSEdOutput | buying | HB School
CS16HiEdOutput | buying | HB Univ
CS17GovOutput | buying | Work-Other
CL23WhiteCollar | selling | HB Work
CL24Services | selling | HB Work
CL25Health | selling | HB Work
CL26Retail | selling | HB Work
CL27BlueCollar | selling | HB Work
CL28Military | selling | HB Work

---

```python
import csv
import os
import chutil
import time

# GLOBAL CONSTANTS

# define the files to access; these are/will be standard.
targetFileName = "TLCtargets1.csv"  # name of target file
groupFileName = "TLCgroups1.csv"  # name of group definition file
histoFileName = "histograms.csv"  # histogram file created by IA
commoditiesFile = "commodities.csv"  # commodities file from AA

outFileName = "TLCCalib.csv"  # output file name
modelCommand = ".\RunAA.sh"  # the file that runs AA

filesToVersion = ['"event.log", "histograms.csv"']  # copy all files in this list a

upperClip = 2.2  # the maximum increase in param. value between iterations
lowerClip = 0.5  # the minimum increase in param. value between iterations
maxIts = 10  # maximum number of iterations to run
gapRange = 0.05  # stop calibration when all errors are +/- this value
initScale = 1.2  # initial scale factor; adjust parameters by this for second run
```

---

This program works on a paramList, which is a list of groups, structured
as follows:
[
0: "name" is the group name (e.g. heavy commercial vehicles)
1: target is the trip length target, taken from whatever skim is used in H1
2: curr param is the parameter for the current / most recent model run
3: curr result is the average trip length from the most recent model run
4: last param is the parameter from the previous run
5: last result is the average trip length from the previous run
]
## AA—Transportation Cost Coefficients

### Transport Coefficients:

<table>
<thead>
<tr>
<th>Commodity Name</th>
<th>Commodity Units</th>
<th>Skim Name</th>
<th>Skim Units</th>
<th>$ / visit</th>
<th>$-util</th>
<th>$ / util</th>
<th>Transport Money Cost Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG10RetailOutput</td>
<td>$HBNW</td>
<td>utils</td>
<td>0.02708</td>
<td>138.97</td>
<td></td>
<td>-0.5315000</td>
<td></td>
</tr>
<tr>
<td>CS13OtherServOutput</td>
<td>$HBNW</td>
<td>utils</td>
<td>0.02569</td>
<td>146.48</td>
<td></td>
<td>-0.5315000</td>
<td></td>
</tr>
<tr>
<td>CS14HealthOutput</td>
<td>$HBNW</td>
<td>utils</td>
<td>0.00282</td>
<td>1,335.48</td>
<td></td>
<td>-0.5315000</td>
<td></td>
</tr>
<tr>
<td>CS15GSEdOutput</td>
<td>$HBNW</td>
<td>utils</td>
<td>0.01687</td>
<td>223.03</td>
<td></td>
<td>-0.5315000</td>
<td></td>
</tr>
<tr>
<td>CS16HiEdOutput</td>
<td>$HBNW</td>
<td>utils</td>
<td>0.01265</td>
<td>297.41</td>
<td></td>
<td>-0.5315000</td>
<td></td>
</tr>
</tbody>
</table>

### Household Obtained Services

<table>
<thead>
<tr>
<th>Summary</th>
<th>Travel Segment</th>
<th>Travel Segment</th>
<th>$ / $-util</th>
<th>Amount of Commodity Consumed Per Visit</th>
<th>Transport Money Cost Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
AA-Price Estimations

Landlord function - "Think Like a Landlord"

Very few of the observed prices should be at very low vacancy rates, perhaps one or two observed prices could be below the lowest observed vacancy rate, but no more than one or two. These are extreme situations that rarely occur in reality.

Curve crosses the y axis above zero - 100% vacancy occurs at a positive price.

Highest observed price should be close to 100% Occupancy

Most observed rents should correspond to typical vacancy rates

Corner should not be too sharp, reduce eta to as low as possible while still meeting the other requirements.
SD: Space Development Module

- Disaggregate process to the parcel level
- Represent developers’ action
- Connection with AA
  - From AA: current year space price at LUZ level
  - To AA: quantity of the spaces for next year AA
- Output
  - Space is a commodity consumed by the activities in the AA model
    - 8 PECAS space types (A/D/S/M/O/R/L/H)
  - Rents are space prices
  - Zoning rules
SD: Development Events

- Year-by-year step
- Possible development events
  - E0: no change
  - En: new space type and quantity
  - Er: alter or renovate
  - Ed: derelict
- Two step process for each parcel
  - Selection of development events and update space type
  - Update space amount
- Data needs
  - Epermits
  - Parcel level data
  - Rents
SD: Parcel Level Data

- For each parcel:
  - Area of the parcel
  - Existing space type
  - Existing space quantity (building floorspace)
  - Structure year
  - **Zoning rules (allowable uses and density range)**
  - Cost and fees (associated with development of each permitted space type and quantity)

- Challenges (20 Counties: every dataset is different)
  - Parcel features and ID
  - Parcel attributes (building floorspace, space type…)
  - Geocoded points for Clayton…
  - Combine parcel with tax assessors' data
  - Updates

- 20-county parcels are cleaned and loaded
  - About 2 million parcels are cleaned

- Benefit other planning projects
So which table has the year a structure was built???
SD: Parcel Level Data

- 20-County parcel features

<table>
<thead>
<tr>
<th>County</th>
<th>Parcels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrow</td>
<td>28,184</td>
</tr>
<tr>
<td>Bartow</td>
<td>42,167</td>
</tr>
<tr>
<td>Carroll</td>
<td>50,633</td>
</tr>
<tr>
<td>Cherokee</td>
<td>93,866</td>
</tr>
<tr>
<td>Clayton</td>
<td>88,723</td>
</tr>
<tr>
<td>Cobb</td>
<td>228,690</td>
</tr>
<tr>
<td>Coweta</td>
<td>55,348</td>
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<tr>
<td>DeKalb</td>
<td>230,888</td>
</tr>
<tr>
<td>Douglas</td>
<td>39,140</td>
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<tr>
<td>Fayette</td>
<td>42,808</td>
</tr>
<tr>
<td>Forsyth</td>
<td>77,639</td>
</tr>
<tr>
<td>Fulton</td>
<td>341,017</td>
</tr>
<tr>
<td>Gwinnett</td>
<td>260,371</td>
</tr>
<tr>
<td>Hall</td>
<td>77,103</td>
</tr>
<tr>
<td>Henry</td>
<td>72,839</td>
</tr>
<tr>
<td>Newton</td>
<td>44,374</td>
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<tr>
<td>Paulding</td>
<td>59,670</td>
</tr>
<tr>
<td>Rockdale</td>
<td>34,780</td>
</tr>
<tr>
<td>Spalding</td>
<td>29,616</td>
</tr>
<tr>
<td>Walton</td>
<td>36,561</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,934,417</strong></td>
</tr>
</tbody>
</table>
SD: Derived Space

- Why do we need the derived space?
  - The quality of the parcel space data: very inconsistent
  - The (in) consistency between employment and space
  - Mixed use issues

- Derived using NAICS employment and Landpro
- New space totals at LUZ and disaggregate to TAZ
- Then, evaluation...

<table>
<thead>
<tr>
<th>SD</th>
<th>SD Name</th>
<th>Constructed RD Space</th>
<th>Constructed RH Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N Fulton</td>
<td>110,515,530.0</td>
<td>20,101,817.0</td>
</tr>
<tr>
<td>2</td>
<td>Roswell</td>
<td>64,773,653.0</td>
<td>18,345,316.0</td>
</tr>
<tr>
<td>3</td>
<td>Sandy Springs</td>
<td>49,058,149.0</td>
<td>14,788,994.0</td>
</tr>
<tr>
<td>4</td>
<td>Buckhead</td>
<td>41,611,473.0</td>
<td>26,465,206.0</td>
</tr>
<tr>
<td>5</td>
<td>NW Atlanta</td>
<td>18,885,490.0</td>
<td>16,171,313.0</td>
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<tr>
<td>6</td>
<td>NE Atlanta</td>
<td>17,768,487.0</td>
<td>35,727,779.0</td>
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<tr>
<td>7</td>
<td>SW Atlanta</td>
<td>33,331,016.0</td>
<td>17,608,331.0</td>
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<tr>
<td>8</td>
<td>CBD Atlanta</td>
<td>9,229.0</td>
<td>3,448,746.0</td>
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<tr>
<td>9</td>
<td>SE Atlanta</td>
<td>22,217,219.0</td>
<td>12,273,079.0</td>
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<tr>
<td>10</td>
<td>S Fulton</td>
<td>25,942,133.0</td>
<td>1,516,626.0</td>
</tr>
<tr>
<td>11</td>
<td>Tri-Cities</td>
<td>18,434,574.0</td>
<td>12,372,604.0</td>
</tr>
<tr>
<td>12</td>
<td>Shannon</td>
<td>32,457,313.0</td>
<td>9,382,727.0</td>
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<tr>
<td>15</td>
<td>W Cherokee</td>
<td>9,352,658.1</td>
<td>8,067,216.0</td>
</tr>
<tr>
<td>16</td>
<td>N Cherokee</td>
<td>3,869,767.2</td>
<td>3,458,062.4</td>
</tr>
<tr>
<td>17</td>
<td>E Cent Cherokee</td>
<td>50,037,301.9</td>
<td>43,281,518.7</td>
</tr>
</tbody>
</table>
SD: Synthesizing to Parcels

- FloorSpace Synthesizer Tool
- Based on existing space type, quantity and zoning...
- Calibration
SD: Synthesizing to Parcels

- Calibration tasks:
  - Evolution of initial synthesized results
  - Directing synthesized development to actual built-on parcels
  - Directing the correct space type to the parcel
  - Directing the synthesized built space to developed parcel in amount resembling actual quantities
SD: Synthesizing to Parcels

- Synthesized results
SD: Rents

- Space prices are rents for the use of space
- Per unit of space per unit of time
- Rent equation: \( \text{Rent}_h = \text{Price}_{h,z} \cdot \pi_{g,zG} \cdot \text{LEFac}_{g,b} \)
  - Space price at LUZ level in AA (done by AA & SD integration)
  - Local-level effects due to the density of development around the parcel
  - Age of the structure
  - Local Effects: distance from (or proximity to) local-level influences
    - Expressway
    - Interstate exit
    - Major road
    - School
    - Marta
    - Green space
### Local effect coefficients

**- Fulton County** - Institutional spaces - Last sold price

<table>
<thead>
<tr>
<th>exponential</th>
<th>INS (r²=0.195)</th>
<th>O (r²=0.155)</th>
<th>R (r²=0.153)</th>
<th>RD (r²=0.194)</th>
<th>RH (r²=0.298)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B</strong></td>
<td><strong>Std. Error</strong></td>
<td><strong>t-ratio</strong></td>
<td><strong>Max. (mile)</strong></td>
<td><strong>B</strong></td>
<td><strong>Std. Error</strong></td>
</tr>
<tr>
<td><em>Constant</em></td>
<td>2.44</td>
<td>0.595</td>
<td>-4.099</td>
<td>1.08</td>
<td>0.397</td>
</tr>
<tr>
<td>Major Road</td>
<td>-0.368</td>
<td>0.126</td>
<td>-2.913</td>
<td>0.9</td>
<td>-0.094</td>
</tr>
<tr>
<td>Freeway</td>
<td>1.504</td>
<td>0.339</td>
<td>4.483</td>
<td>0.25</td>
<td>-0.525</td>
</tr>
<tr>
<td>Freeway Exit</td>
<td>-0.984</td>
<td>0.571</td>
<td>-1.724</td>
<td>0.25</td>
<td>-0.428</td>
</tr>
<tr>
<td>MARTA</td>
<td>0.993</td>
<td>0.837</td>
<td>1.187</td>
<td>0.25</td>
<td>-0.788</td>
</tr>
<tr>
<td>School</td>
<td>-0.844</td>
<td>0.153</td>
<td>-2.035</td>
<td>0.25</td>
<td>0.05</td>
</tr>
<tr>
<td>GreenSpace</td>
<td>0.376</td>
<td>0.903</td>
<td>3.506</td>
<td>4.44</td>
<td>0.12</td>
</tr>
</tbody>
</table>

**Neg exponential**
SD: New SD Database

- Migrated SD databases to PostgreSQL
- New database schema
- 20-County SD database are loaded
  - 2 million records in the parcel table
  - 10 million records in the local effect table
  - More pseudo parcels
  - AND these numbers are for one year of data....
Where It Has Taken Us...Today

- An integrated model run through time, with scenario evaluation
  - AA > SD > AA, 2005 through 2006
  - A scenario of increased transportation costs
  - AA running Region wide, but physical development only in Fulton County
    - Maps of results to follow
  - Sets the stage for further calibration (Stage 3)

- Capability for Full 20-county Run
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

Less than 20K HH Income Household Change
-414
-413 - 0
1 - 13
14 - 101
102 - 246
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs

From Years 2005 To 2006

Greater than 100K Income Household Change

-504 - -225
-224 - 0
1 - 78
79 - 375
376 - 1006
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

Demand Change (Space)

Exchange Results
CA36HiDenResid
-556,412 - -336,548
-336,547 - -96,599
-96,598 - 0
1 - 239,242
239,243 - 428,256
428,257 - 902,178
902,179 - 2,398,797

Miles
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

Demand CHANGE (Space)

Exchange Results
CA35DetResid
-931,772 - -595,695
-595,694 - -163,903
-163,902 - 0
1 - 355,397
355,398 - 770,838
770,839 - 1,629,167
1,629,168 - 2,962,873

Atlanta Regional Commission
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs

From Years 2005 To 2006

PRICE CHANGE

Exchange Results
CA31Retail

- ($0.24) - ($0.18)
- ($0.17) - ($0.06)
- ($0.05) - $0.02
- $0.03 - $0.10
- $0.11 - $0.22
- $0.23 - $0.43
- $0.44 - $0.92
Scenario Tests- AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs

From Years 2005 To 2006

DEMAND CHANGE (SPACE)

Exchange Results
CA31Retail

-443,261 - -210,424
-210,423 - -85,439
-85,438 - -8,801
-8,800 - 74,150
74,151 - 388,959
388,960 - 780,422
780,423 - 1,509,701

0.255
10 Miles

Atlanta Regional Commission
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs

From Years 2005 To 2006

DEMAND CHANGE (SPACE)

Exchange Results
CA33Inst

-79,547 - 60,793
-60,792 - 17,015
-17,014 - 15,991
15,992 - 55,103
55,104 - 162,746
162,747 - 325,547
325,548 - 520,126
Scenario Tests-AA Results

Initial Scenario v10.1 Phase I Calibration

Double the Transportation Costs

From Years 2005 To 2006

PRICE CHANGE

Exchange Results
CA32Office

- ($1.61) - ($0.90)
- ($0.89) - ($0.45)
- ($0.44) - $0.08
- $0.09 - $0.74
- $0.75 - $1.85
- $1.86 - $5.37
- $5.38 - $13.84

0.255 10 Miles

Atlanta Regional Commission
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

DEMAND CHANGE (SPACE)

Exchange Results
CA32Office

-217,647 - 151,671
-151,670 - 69,907
-69,906 - 0
1 - 87,542
87,543 - 559,429
559,430 - 1,021,390
1,021,391 - 2,410,720

0.25 10 Miles

Atlanta Regional Commission
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs

From Years 2005 To 2006

PRICE CHANGE

Exchange Results
CL23WhiteCollar

-0.005 - 0.003
-0.002 - 0
0.001
0.002 - 0.003
0.003
0.004
0.005 - 0.006
0.006 - 0.011

0.255 10 Miles

Atlanta Regional Commission
Scenario Tests-AA Results

Initial Scenario v10.1
Phase I Calibration

Double the Transportation Costs
From Years 2005 To 2006

DEMAND CHANGE Total Labor Dollars

Exchange Results
CL23WhiteCollar

- ($94,470,722.68) - ($49,962,036.01)
- ($49,962,036.00) - ($12,453,059.64)
- ($12,453,059.63) - $0.00
- $0.01 - $38,847,558.38
- $38,847,558.39 - $79,456,117.50
- $79,456,117.51 - $239,463,907.37
- $239,463,907.38 - $599,244,652.14
Labor Travel Change

White Collar Travel Distance by Total Value of Labor

Total Value of Labor

Travel Distance in Miles

Double Tr Cost

No Increase
Labor Travel Change
Blue Collar Travel Distance by Total Value of Labor

Total Value of Labor

Travel Distance in Miles

- Double Tr Cost
- No Increase
Comparison

White Collar

Blue Collar

Total Value of Labor

Travel Distance in Miles

- Double Tr Cost
- No Increase
Scenario Tests-SD Results
PECAS Task List–Progress

**Task group 1 SD Development**
01: Establish parcel-level space rent equations
02: Establish space transition costs calculation system
03: Establish space maintenance costs equations
04: Maintain base-year parcel database
05: Establish base-year quantities of space by type in each zone
06: Establish all-year parcel-level inputs for calibration period
07: Identify space transition constants

**Task group 2 Transport Utility Equation Establishment**
08: Establish transport utility equations

**Task 3 Technology Option Point Development**
09: Identify household technology option points:
10: Identify industrial technology option points:
11: Identify accounts categories technology option points:
PECAS Task List—Progress

Black= Annual Update  Grey= Completed pre-09  Blue= Complete in 2009  Green = In Process

Task group 4 AA Target Development
12: Develop labor production zonal-level targets:
13: Develop labor consumption zonal-level targets:
14: Develop labor spatial flow targets (CTPP)
15: Develop commodity production zonal-level targets:
16: Develop commodity consumption zonal-level targets:
17: Develop commodity spatial flow targets: (CFS)
18: Develop import and exports targets: (NEEDS REFINING)

Task group 5 Import Export Calibration
19: Establish imports and exports functions equation parameters:

Task group 6 AA Inputs Development
20: Develop skim matrices from transport model: (NEEDS INTG THR TIME)
21: Develop X-Vector Attribute values (e.g. schools, air quality)

Task group 7 Stage 2&3 Calibration
22: Establish buying and selling utility equation parameters
23: Establish size terms for imports and exports in external zones
24: Establish technology allocation utility equation parameters
25: Establish location allocation utility equation sensitivity parameters
26: Establish location allocation utility equation zonal constants

Task group 8 Stage 3 Calibration
27: Set-up semi-automated calibration process
## PECAS Tasks-Document

<table>
<thead>
<tr>
<th>Task ID</th>
<th>Task Description</th>
<th>Approach</th>
<th>Next Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Establish Space Rents and Rent Modifier Equations</td>
<td>select rent modifier equations for SD and code development to handle these rent modifier equations (HBA); LUZ rents from PUMS and Costar input to ExchangeResults; prepare document describing process and results</td>
<td>Next Step</td>
</tr>
<tr>
<td>2</td>
<td>Establish Space Transition Cost System</td>
<td>use RSMeans calculation spreadsheets (San Diego examples) to calculate construction costs per sqft for each space type (ARC), test GIS system for computing fees and transition costs (HBA) and then get these fees and transition costs as GIS layers (ARC) and put into system</td>
<td>Next Step</td>
</tr>
<tr>
<td>3</td>
<td>Establish Space Maintenance Cost Equations</td>
<td>get relevant space maintenance cost data by age and estimate equations - contact Mike Clay for test data (ARC)</td>
<td>Next Step</td>
</tr>
<tr>
<td>4</td>
<td>Establish Base-Year Parcel Database</td>
<td>establish these for all counties (filling where target not observed) using space usage equations calibrated in Task 24</td>
<td>Next Step</td>
</tr>
<tr>
<td>5</td>
<td>Establish Base-Year Space Quantities by Zone</td>
<td>put available (now collected) data into PECAS categories (ARC)</td>
<td>Next Step</td>
</tr>
<tr>
<td>6</td>
<td>Establish All-Year Parcel Inputs for Calibration Period</td>
<td>transform space transition quantities from 'opposites' data into PECAS space types (ARC - doing big ones first, then getting into do more later)</td>
<td>Next Step</td>
</tr>
<tr>
<td>7</td>
<td>Establish Pseudo-Parcel Settings and Space Transition Constants</td>
<td>re-visit design diagram to allocate transport flows to commodities categories (ARC/HBA); develop coefficients in spreadsheet (HBA)</td>
<td>Next Step</td>
</tr>
<tr>
<td>8a</td>
<td>Establish Transport Utility Equations</td>
<td>merge space rent values established in Task 1 with vacancy rate information from Census SF3 and CoStar at LUZ level then fill equations (ARC)</td>
<td>Next Step</td>
</tr>
<tr>
<td>8b</td>
<td>Establish Floorspace Short Run Supply Curves</td>
<td>prepare document describing IMPLAN to PECAS technology options work and results obtained</td>
<td>Next Step</td>
</tr>
<tr>
<td>9</td>
<td>Identify Household Technology Option Points</td>
<td>prepare document describing IMPLAN to PECAS technology options work and results obtained</td>
<td>Next Step</td>
</tr>
<tr>
<td>10</td>
<td>Identify Industrial Technology Option Points</td>
<td>prepare document describing IMPLAN to PECAS technology options work and results obtained</td>
<td>Next Step</td>
</tr>
<tr>
<td>11</td>
<td>Identify Accounts Categories Technology Option Points</td>
<td>pull labor by PECAS occupation at place of residence from CTPP-Table 1 to extent possible</td>
<td>Next Step</td>
</tr>
<tr>
<td>12</td>
<td>Develop Labour Production Zonal Level Targets</td>
<td>note: labor by industry established from ARC employment by NAICS data - used to allocate activity totals; next step: pull labor by PECAS occupation at place of work from CTPP-Table 2 to extent possible</td>
<td>Next Step</td>
</tr>
<tr>
<td>13</td>
<td>Develop Labour Consumption Zonal Level Targets</td>
<td>identify relevant targets from data provided by Guy (ARC) and from CTPP-Table 3 for all occupations combined and split into PECAS occupations to extent possible from ARC travel survey</td>
<td>Next Step</td>
</tr>
<tr>
<td>14</td>
<td>Develop Labour Spatial Flow Targets</td>
<td>note: using activity values as allocated and make rates as coded in model; Next step: Document how activity constraints developed and results obtained (note that these are now coded into ActivityConstraints!)</td>
<td>Next Step</td>
</tr>
<tr>
<td>15</td>
<td>Develop Commodity Production Zonal Level Targets</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What’s Next?: 2010+ PECAS Work Plan

• Zoning Data Development
• Evaluation of Model Output over a thirty-year planning horizon
  – Sensitivity testing for the parameters developed in Stage II (during 2009)
  – Calibration of floorspace synthesizer, space transition costs and constants, and dispersion parameters as needed
• Limited testing with varied TDM networks
2010+ PECAS Work Plan

• Review/Analysis of New or Updated Data to modify parameters as needed
  – IMPLAN, CoStar, Means, ACS PUMS, Other

• Directory Structure Improvements/Rsync
  – Refinement of coded scripts >> enhanced integration of the AA and SD modules through time (year by year), full integration of the ARC transport model (ultimately, tour-based)
  – GUI Interface work (possibly)/ GIS linkages
On the Shoulders of In Tandem with...

- Portland and Oregon
- Baltimore
- Montgomery
- California
  - San Diego (SANDAG)
  - LA (SCAG)
  - SF (ABAG)
  - Statewide (CALTRANS)
- Others?
The Goals of 2010+ Work?

• Use PECAS directly as ARC’s small area allocation model in the NEXT conformity modeling process (next RTP/RDP)

• Use PECAS scenario modeling ability to shape and inform policy development, rather than just to test ‘existing’, already formulated policy
Current and Future Reference...

FORECAST DEVELOPMENT

Last modified Thursday, May 08, 2008 9:46

Regional Forecasting (Central Totals):

The New ARC Regional Model(s)—REMI and IMPLAN

In January 2007, ARC began reviewing new forecasting models to replace the current model in use (IPF), which is a FORTRAN open source code model developed in the 1970s. ARC selected REMI, supported by input-output data from the IMPLAN model.

Small Area Forecasting (Land Use Allocation):

The New ARC Small Area Model—PECAS

In conjunction with a selected regional forecast model, ARC began reviewing state-of-the-art land use models to replace current model in use (ERAM/EMPAUL or CBE). After a thorough evaluation, ARC decided that PECAS (Production Exchange Consumption Allocation System) was the best choice. This model is currently used, with varying degrees of completeness, in San Diego, Baltimore, and Montgomery, Maryland, and a statewide model for California is underway.

The theoretical basis for PECAS is the general economic theory. PECAS applies general input-output (IO) modeling theory to subregional zones to model the economic activity (transactions) between the zones.

The modeling produces detailed economic variable output at the small scale. Given the increasing weight of future infrastructure decisions, PECAS (long-term) will be able to help policy makers...