Land Use Models

presented by

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Presentation Outline

• Overview of various types of land use models
• Florida Land Use Allocation Model (FLUAM)
  – Model overview
  – Model structure
  – Model variables
  – Land use data inputs
  – Model execution
  – FLUAM input and output files
  – Travel Demand/Land Use Model Integration
Land Use Models:

– Use economic theories and simplified statistical methods to explain and estimate the layout of land uses

– Are quantitative methods used to predict future changes in land uses based on economic theories and social behaviors

– Can be integrated with transportation models to simulate the interdependent relationships between land uses and the transportation network

– Help determine the various impacts to the transportation network of various land use policies
Typical Base Year Data Sources

- Parcel data
  - Property appraiser data available from the Florida Department of Revenue
- Zoning/Existing Land Use
- Water/sewer service
- Building permits
- Bureau of Economic and Business Research (BEBR) and Census data
- InfoUSA or Bureau of Economic Analysis (BEA) data
- Environmental constraints
- Model data such as networks and skims
Additional Forecast Year Data Sources

- Future Lane Use Maps (FLUM)
  - Planned Unit Developments (PUDs)
  - Evaluation and Appraisal Reports (EARs)
  - Redevelopment plans
- BEBR and BEA forecasts
- Development of Regional Impacts (DRIs)
- Urban Service Areas
- Master/sector plans
- FSUTMS model future year data
  - Networks and skims
Overview of Florida Land Use Models

- Future Land Use Allocation Model (FLUAM) used by Metroplan Orlando and others
- Urban Land Use Allocation Model (ULAM)
- Land Use Conflict Identification Strategy (LUCIS)
  - LUCIS Trend
  - LUCIS Composite
- SLEUTH
- Florida Land Use Allocation Model (FLUAM) from Turnpike developed by RSG
- Others
### Sampling of MPO Land Use Models

<table>
<thead>
<tr>
<th>MPO/TPO</th>
<th>LUCIS Trend</th>
<th>LUCIS Composite</th>
<th>FLUAM</th>
<th>ULAM</th>
<th>SLEUTH</th>
<th>Other</th>
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<td>Indian River MPO</td>
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<tr>
<td>Florida’s Turnpike</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FLUAM*</td>
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</table>
Florida Land Use Allocation Model - FLUAM

- Originally developed by Resource System Group (RSG) in conjunction with AECOM for Turnpike applications
- Gravity model-based
  - In the same category as DRAM/EMPAL land use models
- Uses parcel data information
- Been in use for over 9 years
- Used in the Turnpike State Model (TSM)
- Used in the Turnpike Central Florida Model (TCFM)
- Potential for use in the Cube/Voyager FLSWM
• Growth centers can be geographically defined by the user
  – State, County, MPO, other.
• Allocates housing and employment growth at TAZ level
• Written in C++ and integrated with transportation models:
  – Currently integrated into Florida’s Turnpike State and Central Florida Models
  – Built to allow integration into Cube/Voyager models
• FLUAM Model runs in 2-4 minutes
Overview of the FLUAM Process

Base Year Zonal Land Use
- Households
- Employment

Generate Travel Impedance Matrix

Total Land Available

Determine Remaining Developable Land

Accessibility and Overall Attractiveness

Allocate new Increment of Land Use

TAZ Land Use Forecasts
- Households
- Employment

Legal & Physical Constraints

Florida - Calibrated Parameters

Future Growth Increment
- Households
- Employment

Forecasting Analysis Procedures

5 Year Dynamic Land Use Lag
FLUAM Process – Key Inputs

- **Households**
  - An extension of the population forecasts
  - Uses BEBR forecasts
  - Guided by persons per household trends
  - Assumes relatively stable household sizes with some decay

- **Employment**
  - Uses Bureau of Economic Analysis (BEA) information
  - Historical data for all counties 1969 through 2009
  - Least squares trend analysis used to develop growth rates out to 2045
  - Housing to employment ratio used to check that the employment was sufficient to service the projected population growth
1. What percent of the available land is consumed?

Logit Model Estimates:

\[ P_{ij} = Pr(Y_{ij} = 1 \mid X_{ij}) = \frac{e^{\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k}}{1 + e^{\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k}} \]

\[ P_{ij} = \text{Probability of TAZ i, land use j, being developed} \]

2. What will be the additional households and employment on the consumed land?

Tobit Model Estimates:

\[ \text{Density}_{ij} = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon \]

\[ \text{Density}_{ij} = \text{amount of land use j in TAZ i} \]
<table>
<thead>
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<th>Variable</th>
<th>Source</th>
<th>Effect on Development</th>
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<td>Accessibility</td>
<td>Travel demand model</td>
<td>Positive</td>
</tr>
<tr>
<td>Proximity to Coast</td>
<td>GIS layer</td>
<td>Positive</td>
</tr>
<tr>
<td>Distance from Arterials &amp; Interchanges</td>
<td>Travel demand model</td>
<td>Negative</td>
</tr>
<tr>
<td>Urban Growth Boundary</td>
<td>GIS layer</td>
<td>Positive inside UGB; negative outside</td>
</tr>
<tr>
<td>Percent of Undeveloped/Vacant Land</td>
<td>Parcel</td>
<td>Positive</td>
</tr>
<tr>
<td>Density of Current Use</td>
<td>Parcel</td>
<td>Positive</td>
</tr>
<tr>
<td>Land Category</td>
<td>Parcel</td>
<td>Negative</td>
</tr>
</tbody>
</table>
Sensitivity to Accessibility Example

- Approximate Population to Employment Ratio
  - Cape Coral: 3 pop to 1 emp
  - Fort Myers: 1 pop to 2 emp

- Doubling of bridge capacity during 1990s

- Large subsequent observed increase in development in Cape Coral
  - Population increase by 75% between ’95 – ’05
  - Twice the rate of growth in the 80s and early 90s

- Modeled removal of new bridge capacity
  - Population increase by 55% between ’95 – ’05 (as compared to 75% with the bridges)
Development of Land Use Parcel Data

Cape Coral
Fort Myers
Cape Coral

Development Period
Not Developed as of 2005
1980 or Prior
Since 1980
Undevelopable

Road Network
Four key parcel data variables

- Land use codes
- Land value
- Building square footage
- Year built
Parcel-level development over time
Parcel Data Aggregation

Roll-up of parcel information to the TAZ level

1 TAZ

300+ Parcels
Aggregation of Land Categories

• Agricultural Land
• Developed Residential Land
• Developed Non-residential Land
• Vacant Residential Land
• Vacant Non-residential Land
• Undevelopable Land
Large Land Use Developments

Large developments and the FLUAM
Agricultural Lands in the FLUAM
Underutilized Lands in the FLUAM
FLUAM Execution – Option 1

• Launched like any Windows Application
• File Menu:
  – Load Background – see screen capture
  – Exit – close the application
• Model Menu:
  – Run FLUAM - runs the model and reads an input file called FLUAM_ControlFile.txt located in the same directory as the executable
• Help Menu:
  – About - tells you which version of the FLUAM you are using
• When FLUAM is launched from the command line, the application starts, reads the input control file, runs, then automatically closes.
• Two parameters are required: the executable including path and the input control file including path.
• Two sample command lines are shown below (quotes are required around each parameter). An easy way to perform this step is through a batch file.

  “C:\TSM\FLUAM.EXE” “C:\TSM\FLUAM_DATA\CONTROL_FILE.TXT”

  Or

  “fluam.exe” “ControlFile.txt”
Control File - Overview

• Consists of sections each defined by a header. Headers must be written exactly as shown below (must be upper case with the //**)

• //** VERSION
• //** GENERAL PARAMETERS
• //** FILE NAMES
• //** RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
• //** NON-RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
• //** RESIDENTIAL DENSITY COEFFICIENTS
• //** NON-RESIDENTIAL DENSITY COEFFICIENTS
The control file version number must be consistent with the application (which can be viewed from Help::About menu).

```/**
* //** VERSION
* 2010 // version 2.0.1.0 corresponding to the File::About menu
```
General parameters define run flow and overall values.

```plaintext
//** GENERAL PARAMETERS
0    // 1 = dump debug files, 0 = don't
0    // 1 = new skim, 0 = skim represented in input TAZ file
0    // 1 = new network, 0 = network is in input TAZ file
4837 // LastInternalZone
4874 // LastExternalZone
100  // ClosestNTAZs
-1.7354 // TravelTimeAdjustment
```
This specifies the input and output files to be used in the model run

- /** FILE NAMES
- C:\FLUAM\DATA\travel_times_15.txt // INPUT: auto travel time skim
- C:\FLUAM\DATA\TAZ_15.txt // INPUT: TAZ input file
- C:\FLUAM\DATA\Growth_15_20.txt // INPUT: growth file (control totals)
- C:\FLUAM\DATA\Nodes_15.txt // INPUT: node file
- C:\FLUAM\DATA\Links_15.txt // INPUT: link file
- C:\FLUAM\DATA\TAZ_Out_15.txt // OUTPUT: current zonal output file
- C:\FLUAM\DATA\TAZ_OutIn_20.txt // OUTPUT: future zonal output file
The remaining four sections specify the model parameters. These should not be changed. They are available simply to provide documentation and for access in future calibration efforts.

- /** RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
- /** NON-RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
- /** RESIDENTIAL DENSITY COEFFICIENTS
- /** NON-RESIDENTIAL DENSITY COEFFICIENTS
• Auto travel time file from the most previous transportation assignment.
• Exported via a script
• File structure: CSV file.
• Three columns (from TAZ, to TAZ, Time)

1, 1, 32
1, 3, 28
1, 1, 12
• Node File: Extracted from the model network.
• File Structure: CSV Format
• Sample File:
  
  N, X, Y
  1, 403760, 2987443
  2, 378206, 2987949
  3, 383076, 2989870
Link File

- Link File: Extracted from the model network
- File Structure: CSV Format
- Sample File:
  
a, b, district, distance, oneway, lane_05, ftype_05, atype_05, speed_05, cap_05, fftime_05

1, 51493, 1, 2, 2.21023, 0, 2, 51, 30, 35, 10000, 3.78897
1, 52148, 1, 1, 1.22329, 0, 2, 51, 30, 35, 10000, 2.09707
1, 52163, 1, 1, 1.27246, 0, 2, 51, 30, 35, 10000, 2.18136
2, 53485, 1, 1, 1.3796, 0, 2, 51, 50, 35, 10000, 2.36503
2, 84608, 1, 1, 0.89797, 0, 2, 51, 50, 35, 10000, 1.53938
• Contains the housing and employment control totals for each “Growth Center”
• Each TAZ is assigned to a Growth Center in the TAZ file (described next). Growth Centers currently follow County boundaries
• File Structure: CSV Format
• Sample File:

<table>
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<tr>
<th></th>
<th>Housing Units</th>
<th>Employment</th>
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<td>2, 234, 834</td>
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<td>3, 163, 256</td>
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<td>...</td>
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<tr>
<td>67</td>
<td>264, 526</td>
<td></td>
</tr>
</tbody>
</table>
**TAZ File**

- **TAZ File includes:**
  - Input values: used as input to the model run
  - Temporary values: both input and output
  - Output values: results of the model run

**Temporary values** are intermediate variables calculated during the model run. These can be used as a starting point for a new model run (see the second and third values in the GENERAL PARAMETERS Section of the control file)

The TAZ file is used to hand output from one time step into the next time step
OUTPUT TAZ Files

/** FILE NAMES
• C:\FLUAM\DATA\travel_times_15.txt // INPUT: auto travel time skim
• C:\FLUAM\DATA\TAZ_15.txt // INPUT: TAZ input file
• C:\FLUAM\DATA\Growth_15_20.txt // INPUT: growth file (control totals)
• C:\FLUAM\DATA\Nodes_15.txt // INPUT: node file
• C:\FLUAM\DATA\Links_15.txt // INPUT: link file
• C:\FLUAM\DATA\TAZ_Out_15.txt // OUTPUT: current zonal output file
• C:\FLUAM\DATA\TAZ_OutIn_20.txt // OUTPUT: future zonal output file

This file contains the same inputs as were in the input TAZ file (second file listed in this section). It will have updated temporary and output values. This file is designed to be used as input to another run of the same time step.
**FILE NAMES**

- `C:\FLUAM\DATA\travel_times_15.txt` // INPUT: auto travel time skim
- `C:\FLUAM\DATA\TAZ_15.txt` // INPUT: TAZ input file
- `C:\FLUAM\DATA\Growth_15_20.txt` // INPUT: growth file (control totals)
- `C:\FLUAM\DATA\Nodes_15.txt` // INPUT: node file
- `C:\FLUAM\DATA\Links_15.txt` // INPUT: link file
- `C:\FLUAM\DATA\TAZ_Out_15.txt` // OUTPUT: current zonal output file
- `C:\FLUAM\DATA\TAZ_OutIn_20.txt` // OUTPUT: future zonal output file

This file contains updated input data representing the results of the model run. It is designed as an input to the FLUAM run in the next time step.
- Run traffic assignment for period (t)
- Run LUAM for (t+5) using period (t) skim values, period (t+5) control totals
- Calculate FRATAR factors for updating trip table to period (t+5)
- Repeat process for all forecast periods
FLUAM/Travel Demand Model Integration

Base Year Land Use

Relationship between base year land use and trip ends
- Regression

Base Year Calibrated Trip Table

ME/Assignment
- ME
- Assignment

Land Use Allocation Model

New Housing & Employment by TAZ Totals

FRATAR Process/Future Trip Table Development
• The future year trip ends are estimated based on a calculated relationship between the base year calibrated OD matrix trip ends and the base year land use.

\[
\text{TripEnds}_i = 3.61 \times \text{Employment} + 1.88 \times \text{Households} \quad \text{(rural TAZs)}
\]

\[
\text{TripEnds}_i = 3.95 \times \text{Employment} + 1.88 \times \text{Households} \quad \text{(transition TAZs)}
\]

\[
\text{TripEnds}_i = 3.02 \times \text{Employment} + 1.88 \times \text{Households} \quad \text{(urban TAZs)}
\]
FRATAR Process continued

- A spreadsheet is used to generate the input to the FRATAR process.
- The spreadsheet:
  - Takes the future land use from FLUAM (yellow)
  - Estimates future trip ends based on this land use (blue)
  - Calculates the growth factor between the calibrated matrix (2010) and the future year (2015)
  - Generates the input to the FRATAR process (far right)

<table>
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<td>3514</td>
<td>4466</td>
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</tr>
</tbody>
</table>
• The FLUAM facilitates future year trip table development
• The FLUAM is part of a process that incrementally builds the future land use out to a horizon year (2045)
• The FLUAM is a stand alone process
  – Adaptable/flexible
  – Tool that is good at using many database layers
• Can be integrated into the Cube/Voyager platform
  – Customizable and able to be adapted to the Cube environment and variables
• Potential exists for use in the Florida Statewide Model (FLSWM)
  – Cube environment
  – Navteq integration
Questions

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