Land Use and Transport Modeling for Sustainability Goals

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Outline

- Project Topics
- Land Use & Transport Modeling
  - Background on Land Use/Transport Modeling
  - UrbanSim
  - Example, Salt Lake City, Utah
- Discussion of Assignment 3
- Intro to Assignment 4
Part I

LAND USE/TRANSPORT MODELLING

Prerequisites

For all planning (?

- A method to foresee future consequences of present actions
- A framework to assess if an outcome is good or bad
Relevant trends

- Trend extrapolation
- Experience
- Transport demand
  - Trips: Frequency, mode, destination
  - Activities: What, where, and when
- Transport supply (assignment)
  - Static equilibrium
  - Dynamic
  - Simulation
Modelling: What we try *not* to do

MY HOBBY: EXTRAPOLATING

AS YOU CAN SEE, BY LATE NEXT MONTH YOU’LL HAVE OVER FOUR DOZEN HUSBANDS. BETTER GET A BULK RATE ON WEDDING CAKE.

Travel Demand Modelling

Four-Step Disaggregate Travel Models:
- Trip Generation – how many?
- Trip Distribution – where?
- Mode Choice – how?
- Trip Assignment – what route?

Extensions:
- Joint trip distribution-mode choice
- Auto ownership modelling
Transport models

- **Forecast assumptions**: (GDP, population, etc)
- **Forecast model**: Demand (discrete choice) \rightarrow Supply (assignment)
- **Effect/Impact models**: (Pollution, CO2, accidents, etc)
- **Appraisal**: (Valuation, discounting, presentation)

Model properties

- **Linear-in-parameters**
  - E.g. trade-off between time & cost
  - Estimated on travel surveys
- **Policies**
  - Infrastructure changes (affects travel time & distance)
  - Pricing (transit fares, congestion charges, fuel tax)
  - Land use scenarios
- **Not linear in response!**
  - Not constant elasticity of substitution
  - Non-linear travel times (congestion)
Always a comparison between scenarios!

Compared to what?

<table>
<thead>
<tr>
<th>Investments</th>
<th>Land use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Today</td>
</tr>
<tr>
<td>Base case (no changes)</td>
<td><img src="image1.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Alternative 1</td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Alternative 2</td>
<td><img src="image3.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Alternative 3</td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Activity-Based Travel Modelling

Explicit representation of trip chains:

![Diagram](image5.png)

Kuzmyak et al 2012
Integrated Land Use-Transport Modelling

Regional accessibility
• Household and job location choices
• Density & mix of uses
• Activities
• Travel patterns
• Regional accessibility

Wegener & Fürst 1999

More complex interdependencies →

Integrated Land Use-Transport Modelling

Wegener & Fürst 1999
Urban Sim

- Integrated planning and analysis of urban development
- Software-based simulation model
- Open source license
- Led by Paul Waddell (UC Berkeley)
Key Features

- Models Actors Making **Discrete Choices**:
  - Household Mobility and Location Choice
  - Business Mobility and Location Choice
  - Developer Land Development/ Redevelopment
- Takes Some Things As **Given**:
  - Governmental Decisions; Population & Jobs
- **Dynamic** In Nature:
  - Runs in one-year time-steps
  - Path-dependent (history matters)
  - Adjustment toward equilibrium in long-run

Key Features (cont.)

- Simulates Incremental Decisions of Urban Actors
- Explicit Representation of:
  - Land, Buildings and Occupants
  - Land Market and Prices
  - Government Policy and Infrastructure
Policy Inputs

- **Regional Trends:**
  - Total Population and Jobs

- **Development Constraints:**
  - Land use plans
  - Environmental protections
  - Physical constraints (water, steep slopes)
  - Legal constraints

- **Transportation infrastructure**

- **Unique Events**
  - Planned developments
  - Planned future development controls
  - Corporate relocations

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Internal Model Cycle

1. **Zone-Specific Accessibilities**
2. **Synthesis or Deletion of Jobs & Households**
3. **Identify Jobs & Houses that will Relocate This Year**
4. **Identify New Locations of Relocating Jobs & Households**
5. **Simulate Development of New Real Estate**
6. **Update Estimated Land Values**
7. **Export Data to MySQL Output Database**
External Model Cycle

1. Accessibility
2. Economic &
   Geographic
   Transition
3. Mobility
4. Location
   Choice
5. Real Estate
   Development
6. Land
   Price
7. Data
   Export

Scenario Assumptions & User Events

Base Year Conditions;
Constraints & Distinct Events;
Model Specifications and Parameters

Macroeconomic Model

Household & Employment
Control Totals
By Type and Year

Travel Demand
Model

Travel Times & Costs

Household and
Job Locations

Part III
CASE STUDY:
SALT LAKE CITY, UTAH
Background

Salt Lake City
- Capital of State of Utah
- Home of “Mormon” Church
- City: 186,000 pop
- Metro: 1,124,000 pop
- Region: 2,238,000 pop
Bounded by Mountains and the Great Salt Lake
Transportation:
- Motorways, Ring-Road
- 31-km Tram (3 lines)

1996—2000
“Quality Growth Efficiency Tools”

Comprehensive package of regional transport projects
- Light Rail
- Transit-Oriented Development
- New Highway: Legacy Parkway
1996—2001
Environmental Review

Environmental Impact Statement (EIS)
  • Required by law to assess impacts of major projects on the environment

Approved in 2001

2001
Lawsuit

Sierra Club & Mayor of Salt Lake City sue the Utah Department of Transport
Argued that EIS was flawed:
  • Did not account for wetlands impacts
  • Did not account for induced urban development
2002 (Winter Olympic Games) Settlement Agreement

Parties Agree to Re-Examine Urban Growth Impacts
- Using UrbanSim*
- Provided that UrbanSim passes a Peer Review

*UrbanSim was already under development
- Interest in land use modeling since 1997
- Experiments with UrbanSim up to 2002

2003 Peer Review of UrbanSim

Run UrbanSim on the Base scenario:
- Existing Long Range Plan (without Legacy Parkway)
Run UrbanSim on some other scenarios besides the Legacy Parkway (which was politically sensitive):
- E.g. Urban Growth Boundary
Model Results

LONG RANGE PLAN SCENARIO

LRP Scenario
Access to Employment

1997  2030  Change
Model Results

**URBAN GROWTH BOUNDARY (UGB) SCENARIO**

**UGB Scenario**
**Roadway Volume-to-Capacity Ratio**
UGB Scenario
Employment

Model Results
“REMOVE A HIGHWAY”
Omit Highway Scenario
Roadway Volume-to-Capacity Ratio

Omit Highway Scenario
Access to Employment
Omit Highway Scenario Population

Omit Highway Scenario Population
### Summary across Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>VMT (000s)</th>
<th>VHT (000s)</th>
<th>TCD (000s)</th>
<th>Transit shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base (1997)</td>
<td>39,463</td>
<td>1,695</td>
<td>110</td>
<td>2.38%</td>
</tr>
<tr>
<td>Adopted 2030 forecast</td>
<td>71,182</td>
<td>2,932</td>
<td>250</td>
<td>4.30%</td>
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<tr>
<td>Scenarios modeled with UrbanSim</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-build</td>
<td>75,898</td>
<td>2,343</td>
<td>298</td>
<td>4.26%</td>
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<tr>
<td>Highway</td>
<td>74,760</td>
<td>2,127</td>
<td>291</td>
<td>4.24%</td>
</tr>
<tr>
<td>Transit</td>
<td>75,184</td>
<td>2,154</td>
<td>303</td>
<td>4.05%</td>
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<tr>
<td>Parking</td>
<td>74,797</td>
<td>2,132</td>
<td>295</td>
<td>4.44%</td>
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<tr>
<td>UGB</td>
<td>72,580</td>
<td>2,094</td>
<td>289</td>
<td>4.47%</td>
</tr>
</tbody>
</table>

Comparison to adopted 2030 forecast:
- UrbanSim LRP: +5.44%  +5.44%  +15.54%  -0.04%

Comparison to UrbanSim LRP scenario:
- No-build: +30.3%  -30.7%  +256.4%  -2.3%
- Highway: -0.7%  -0.7%  -2.3%  0.0%
- Transit: -0.2%  +0.5%  +1.9%  -0.2%
- Parking: -0.3%  -0.5%  -0.9%  +0.3%
- UGB: -3.3%  -2.3%  -3.6%  +0.2%

* VMT is vehicle miles travelled.
* VHT is vehicle hours travelled.
* TCD is total hours of congestion delay.
* Transit shared is the transit mode share for the hour-based work trip purpose.
* LRP is the WFRP Long Range Plan.
* UGB is an urban growth boundary.

### Comparison to Long Range Plan

- % Change
  - Distance Traveled
  - Time Traveling
  - Congested Delay
  - Transit Shared

- Omrid Highway
- Omrid Transat
- Parking Fees
- Urban Growth Boundary
- No-Build
Comparison to Long Range Plan

Key Findings from Peer Review

UrbanSim seemed to provide realistic results for policy tests, both on land use and transport, at aggregate level.

Sensitivity of land use to new transport infrastructure was very low!

Panel recommended using UrbanSim for regional analysis, but not for corridor analysis.
Rest of the Story: 2004—2006

Regional Government incorporates UrbanSim into planning processes
- Data Problems
- Processing Problems
- Staff Turnover

Rest of the Story: 2004—2006

Revised Environmental Impact Statement
- Proceeds without using UrbanSim
- Only a subjective assessment of induced growth

Conditions for Redesign (valid until 2020):
- No Billboards
- No Trucks
- Speed Limit: 90 km/h

Revised EIS is approved
Construction Resumes
2006—2008
Project Completion
Opened to Traffic Autumn 2008

Legacy Parkway Today

- Shoreline of the Great Salt Lake
- Old Motorway
- Railroad (double track)
- Legacy Parkway

660 meters
The Metropolitan Council Today

WFRC’s Reflections:

• “UrbanSim…requires a dedicated, trained, medium-to-high level programming and modeler resource” (2 individuals for 2 years).

• Each modeling run of UrbanSim took a week or more of programming and data preparation.
  – UrbanSim model was 72 continuous hours
  – Travel model runs took several hours to a day to run.

• This level of resource commitment and modeling time was acceptable, but did not allow for numerous runs or adjustments to the model.

The Metropolitan Council Today

WFRC’s Reflections (continued):

• UrbanSim…was a unique feature that allowed consideration of land use principles before determination of transportation needs.

• Some resistance to the use of UrbanSim as a tool to model population and employment demographics
  – Due to the granularity of the analysis - 150 meter grid
  – And it took additional time.

• Stayed with the 150 meter grid
  – Could be used for detailed work when required
Questions for Reflection

Was the construction of the Legacy Parkway the **right thing to do**?

**What went wrong** with the implementation of UrbanSim?

Can Long Range Planning **rely** on complex urban models?

Should **legal settlements** rely on complex urban models?