Integrated Land Use Transport Models

Building an Integrated Model: Some Guidance

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Current Practice in Integrated Land Use - Transportation Modeling

- Most MPOs have no land use model
- Negotiated land use forecasts common
- No feedback from transportation plan
- Inconsistent with federal guidelines
- Inconsistent with research
- Issue at core of lawsuits
- Presenters here are at the ‘bleeding edge’

Why So Few Integrated Models?

- High data requirements
- High complexity
- High computational demands
- High expertise requirements
- Lots of manual interaction
- High cost (staffing, consulting)
- 3-year RTP Plan update “Treadmill”
- Not much published validation
- Not much sharing of information
- Not enough adopters to tip the balance

…yet

Lee's Requiem – 1973: Assessment of Urban Models

- 7 Deadly Sins of Urban Models
  - Hypercomprehensiveness
  - Grossness
  - Data Hungriness
  - Complicatedness
  - Wrongheadedness
  - Mechanicalness
  - Expensiveness

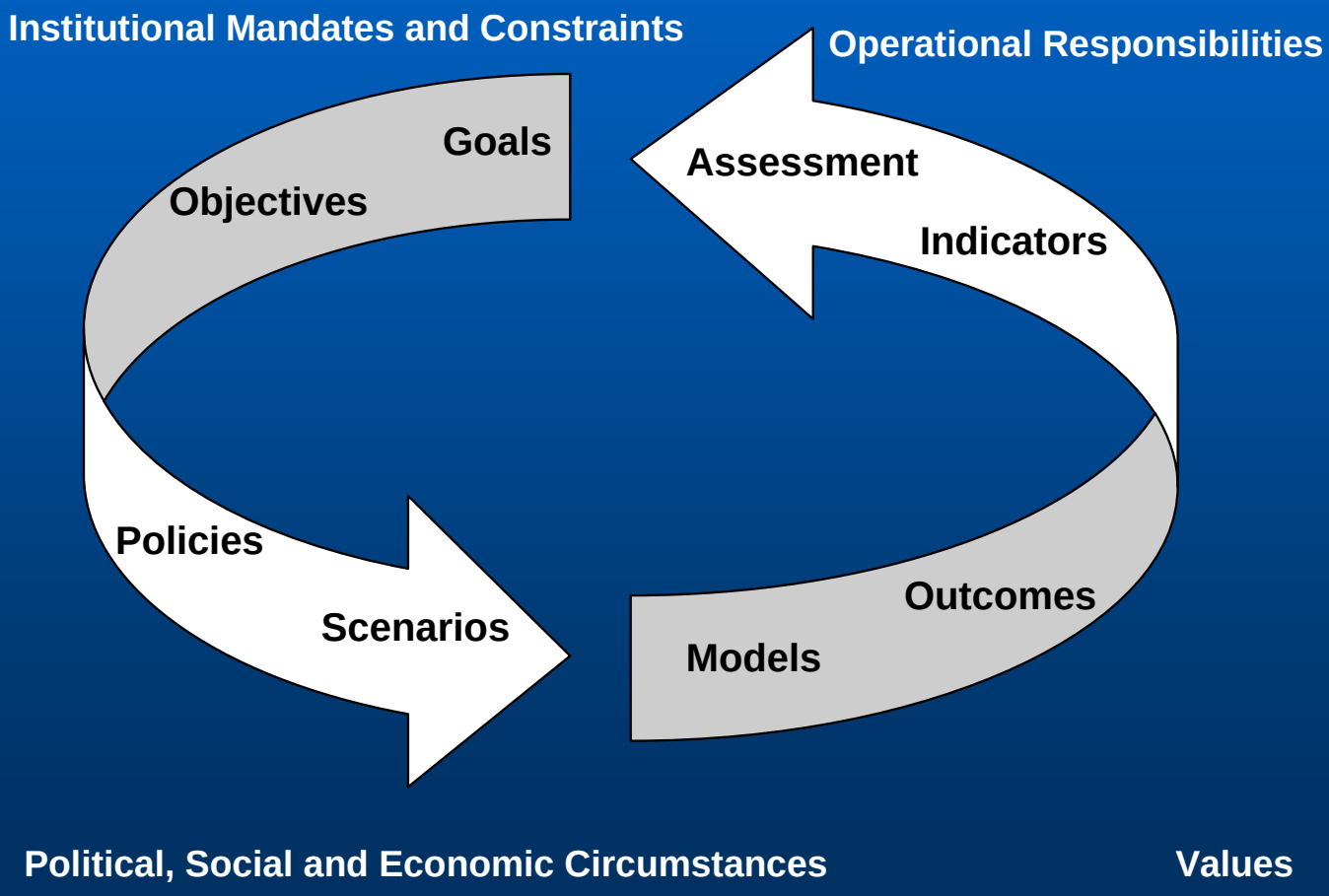
Lee's Requiem – 1973: Assessment of Urban Models

- Recommendations
  - Make models more transparent to policymakers and users
  - Combine solid theoretical foundations, objective information, and wisdom or judgement
  - Start with problems and design models to address problems
  - Build the simplest model possible

What Would Improve the Outlook?

- More published case studies of models:
  - Database development
  - Model estimation and calibration
  - Model VALIDATION!!!
  - Model applications to real decisions
  - Honest assessments:
    - strengths and weaknesses
    - Priorities for improvement
- More collaboration and information sharing among researchers, users, consultants

Recommendations: Understand Use Context



Some Recommendations

- Inventory the policies to be examined by the model
- Involve local governments via Technical Committee
- Assess staffing level and skills
- Assess data limitations
- Decide whether to ‘grow your own’ or build on existing models and software
- Be sure you can sustain the effort:
  - How much consulting support required, and for how long?
  - Does staff level and expertise match the requirements?
  - Are expectations realistic?

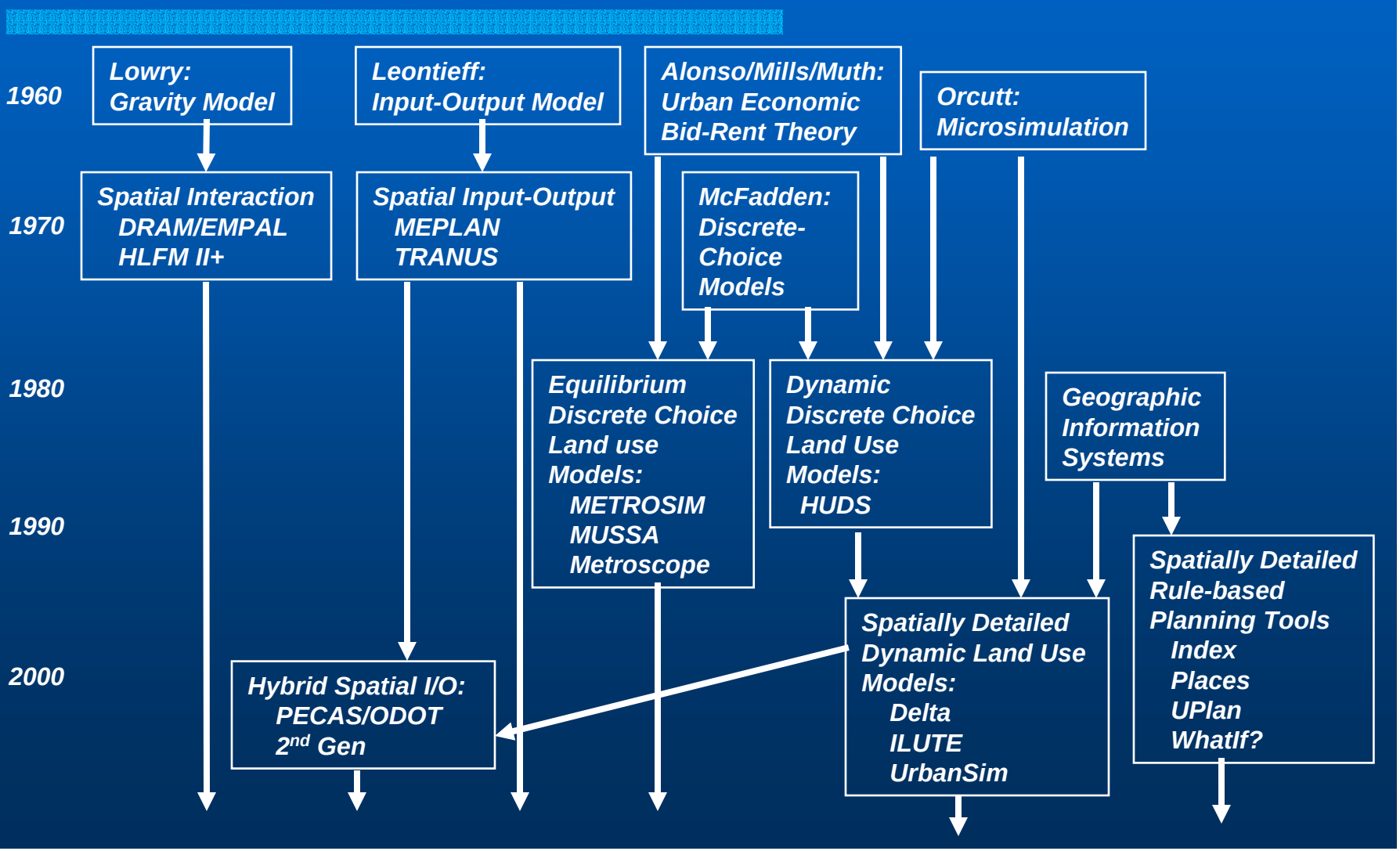
Some Recommendations

- Be realistic on scheduling & work-planning
  - 1+ person years on data preparation
  - 1+ person years on estimation/calibration
  - 1+ person years on validation/refinement
- Get the system running, then improve it
- Phase workplan: get results soon enough to maintain management support
- Don’t under-invest in data development
  - Historical data critical
  - Employment data: 80-20 rule
  - Parcel data: messy but valuable
  - Data cleaning, imputation, synthesis

If You Develop a Land Use Model

- Some design elements are obvious requirements:
  - Household location choice
  - Employment location choice
  - Real estate development (land use)
- Others have growing consensus:
  - Discrete choice structure fits these processes well
  - Need price signals: real estate prices
  - Some form of market clearing
- Others still vary widely:
  - Static or dynamic?
  - Aggregate or microsimulation?
  - Role for frameworks such as spatial input-output, spatial interaction?
  - How geographically detailed?

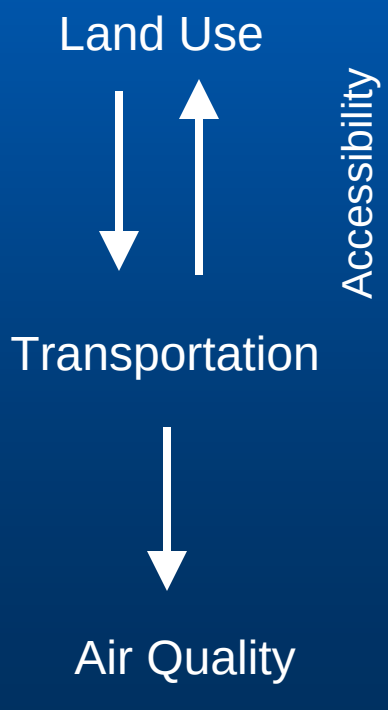
Land Use Modeling Frameworks



Land Use - Transportation Interaction

Traditional Approach

Integrated Modeling



Linking Land Use and Transportation: Alternative Measures of Accessibility

- Access to activity within time threshold
  - How many jobs can you reach within 30 minutes by car, during the AM peak period?

$$Access_i = \sum_j Jobs_j \forall Time_{ij} < X$$

- Advantages
  - Easy to interpret
  - Straightforward to compute
- Disadvantages
  - Arbitrariness of threshold
  - Non-time factors ignored
  - Can it represent influence of multiple modes?

Linking Land Use and Transportation: Alternative Measures of Accessibility

- Logsum-based Measures of Accessibility
  - Accessibility to employment

$$Access_i = \sum_j Jobs_j e^{Logsum_{ij}}$$

Logsum from Mode Choice

- Advantages
  - Non-time factors incorporated
  - Can represent influence of multiple modes
  - Reflects spatial distribution of activities
  - Consistency with mode-choice model
  - Relatively straightforward to compute
- Disadvantages
  - Difficult to interpret
  - Does not reflect information from Trip Distribution

Linking Land Use and Transportation: Alternative Measures of Accessibility

- Trip-Weighted Measures of Accessibility
  - Accessibility for Home-based Work Purpose

$$Access_i = \frac{\sum_j (Trips_{ij} Logsum_{ij})}{\sum_j Trips_{ij}}$$

Logsum from Mode Choice

- Advantages
  - Non-time factors incorporated
  - Can represent influence of multiple modes
  - Reflects spatial distribution of activities
  - Consistency with mode-choice and trip distribution models
  - Relatively straightforward to interpret
- Disadvantages
  - Shows less spatial variation

Linking Land Use and Transportation: Alternative Measures of Accessibility

- Accessibility from Combined Destination and Mode Choice
  - Accessibility for Home-based Work Purpose

$$Access_i = Logsum_i$$

Logsum from Destination & Mode Choice

- Advantages
  - Simple and theoretically consistent
  - Non-time factors incorporated
  - Can represent influence of multiple modes
  - Reflects spatial distribution of activities
  - Consistency with mode-choice and trip distribution models
  - Relatively straightforward to interpret
- Disadvantages
  - Shows less spatial variation

Linking Land Use and Transportation: Alternative Measures of Accessibility

- Activity-based modeling opens new opportunities:
  - Long-term choices given:
  - Residence location
  - Workplace
  - School location
- Accessibility is an **individual** expectation
  - Time
  - Cost
  - Reliability

Recommendations: Model Validation

- Validate components, then system
- No substitute for longitudinal validation
  - Ideally over comparable period to forecast (30 yrs)
  - But historical data is challenge
    - Neighborhood Change Database (NCDB)
    - Zonal employment estimates
  - New Bayesian calibration/validation techniques
- Next-best is Sensitivity Analysis
  - Sledgehammer tests
  - Smaller scale tests
  - Does model respond in expected ways?

A Vision for Moving Forward

- Advancing Practice Needs:
  - Collaboration among modelers, users
  - Ways to make incremental progress
    - Nibbling instead of swallowing the elephant whole
- A Strategy:
  - Open Source Infrastructure
  - Collaborative Organization (Univ, MPO, Consult)
  - Pluggable Modules (Models, Variables, Indicators)
  - Simple Defaults
  - Ways of Benchmarking Improvement
  - Sharing of Data (test beds)
  - An Example: The R Statistical Community

Is there a Perfect Modeling Platform? NO

- What features would be useful to have?
  - Open Source, for transparency, ability to extend
  - Extensive testing framework
  - Clean object-oriented design
  - High-level scripting language to configure models
  - Clear code that is easy to modify
  - Fast computation
  - Behaviorally transparent
  - Database and GIS interface
  - Automated estimation, with uncertainty analysis
  - Integrated generation/visualization of indicators
  - Interactive (GUI) and batch (scripting) modes

Sample Code: Multinomial Logit

```
class Logit:
    """Class for performing multinomial logit calculations"""

    def compute_probability(self,data):
        self.exponentiated_utility = exp(data.utility)
        self.sum_exponentiated_utility = sum(self.exponentiated_utility, axis=1)
        self.probability = self.exponentiated_utility/reshape /
                (self.sum_exponentiated_utility,(data.obs,1))
        self.sum_probabilities = sum(self.probability, axis=1)

    def compute_choice(self,data):
        self.cumulative_probability = cumsum(self.probability, axis=1)
        self.draw = random([data.obs])
        self.choice = reshape(data.alts-sum(where(reshape(self.draw,(data.obs,1))
                <= self.cumulative_probability,1,0),1)+1,(data.obs,1))

    def take(self, gridids):
        choices = zeros((gridids.shape[0],))
        for i in range(gridids.shape[0]):
                choices[i] = gridids[i,self.choice[i,0]-1]
        return choice
```

Evaluating Models: Model Validity

- Is the model structure theoretically sound?
- Is the integration of land use and travel behavior realistic?
- Are the quantitative methods used in the model appropriate?
- Are the estimation results valid?
- Are the simulation results reasonable?
- Is the model appropriately sensitive to constraints and policies of interest? - especially effects of major transportation improvements

Evaluating Models: Usability and Responsiveness to Stakeholder Concerns

- Does it have an effective user interface?
- Is the computing performance adequate?
- Are requirements for data and expertise manageable?
- Does it produce needed indicators for diagnosis and evaluation?
- Does it integrate adequately into the institutional and political context?
- How useful is it in different use cases: regional transportation plan; corridor planning; regional visioning; local community planning?