# The Evolving State of the Practice

Webinar 1 of an 8-part TMIP Webinar series on land use forecasting methods.

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## Land Use Forecasting Webinar Series

1. The Evolving State of the Practice
2. Land Use Theory and Data
3. I-PLACES: Scenario Planning and Visioning
4. PECAS: Spatial Input-Output Frameworks
5. UrbanSim: Dynamic Microsimulation
6. Modeling Real Estate Demand
7. Modeling Real Estate Supply
8. Scenario Planning and Visualization

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## Webinar 1: The Evolving State of the Practice

1. The evolving role of land use in transportation planning
2. Evolving approaches to land use forecasting
   - Pre-1990 Modeling Approaches
   - Post-1990 Modeling Approaches
3. State of the practice
   - What are MPOs doing now?
   - What are the trends?
4. Model assessment and recommendations





1. **The evolving role of land use in transportation planning**
2. Evolving approaches to land use forecasting
3. State of the practice
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# The Evolving Role of Land Use Forecasting: Evolution of Land Use Model Needs

- Prior to 1990
  - Predict travel demand effects of land use
  - Static baseline forecast used for all travel model runs
- Post 1990 (ISTEA/CAAA)
  - Predict travel demand effects of land use
  - Support alternatives analysis
    - Evaluate land use effects of transport projects (induced demand)
    - Evaluate Travel Demand Management (TDM) policies (e.g. pricing)
    - Evaluate land use regulations (e.g. TOD, comprehensive plans)
    - Support growth management strategies
    - Support environmental planning (e.g. greenhouse gas emissions)
    - Support affordable housing strategies
    - Support regional visioning (how to achieve desired outcomes)
    - Assess interactions between policies and real estate markets



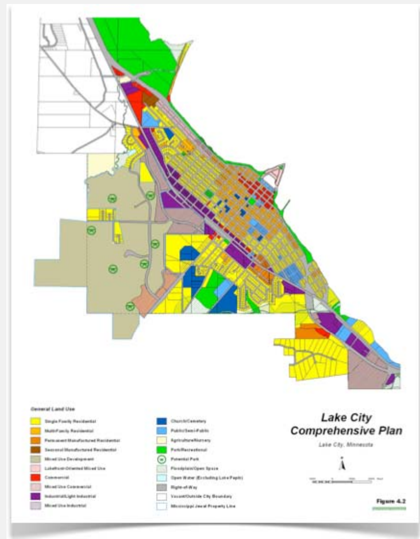


# Informal Methods to Generate Land Use Forecasts

- Informal (Not Model-Based) Procedures:
  - Comprehensive plan ‘buildout analysis’
  - Informal judgement using input from local planners
  - Spreadsheets or GIS tools sometimes used to assist
- Problems with Informal Procedures:
  - Manual process (little or no automation, not repeatable)
  - Require long time frames
  - Not well documented
  - Very difficult to incorporate theoretical or empirical research
  - Susceptible to political pressure from local jurisdictions and other stakeholders
  - Cannot support alternatives analysis

## Comprehensive Plans

- Developed by Local Jurisdictions
- Updated usually every 5 years
- But many jurisdictions still do not have a comprehensive plan
- Do:
  - Provide generalized constraints on nature and density of development
- Do not:
  - Indicate market potential
  - Reflect impact of alternative transportation plans








## Motivations for Using Land Use Models in Transportation Planning

- **Theoretical**: Long-term induced demand from transportation projects
- **Legal**: Federal legislation
  - ISTEA, TEA21, CAAA
  - Require assessment of impacts of transportation improvements on congestion, travel and land use
  - Link land use, transportation and air quality planning
- **Political**: Local and state pressures for smart growth and growth management

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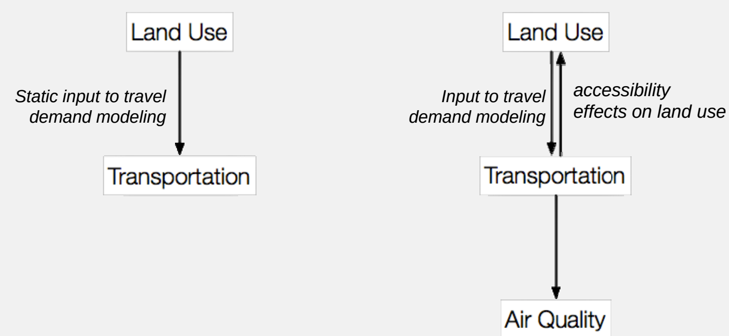
## The Evolving Role of Land Use Forecasting: Land Use - Transportation Interaction

***Traditional Approach*** ***Current Guidelines***



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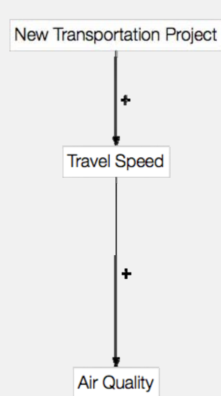
## The Evolving Role of Land Use Forecasting: Long-Term Induced Demand

*Analysis of project effects on air quality, **not** considering land use feedback*



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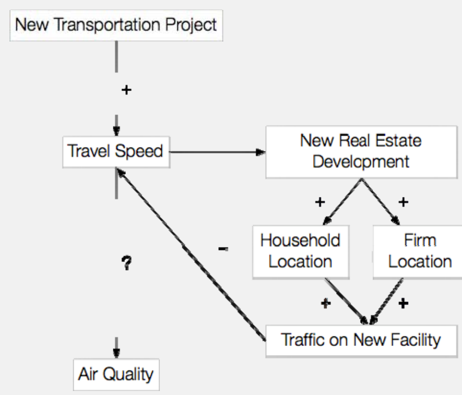




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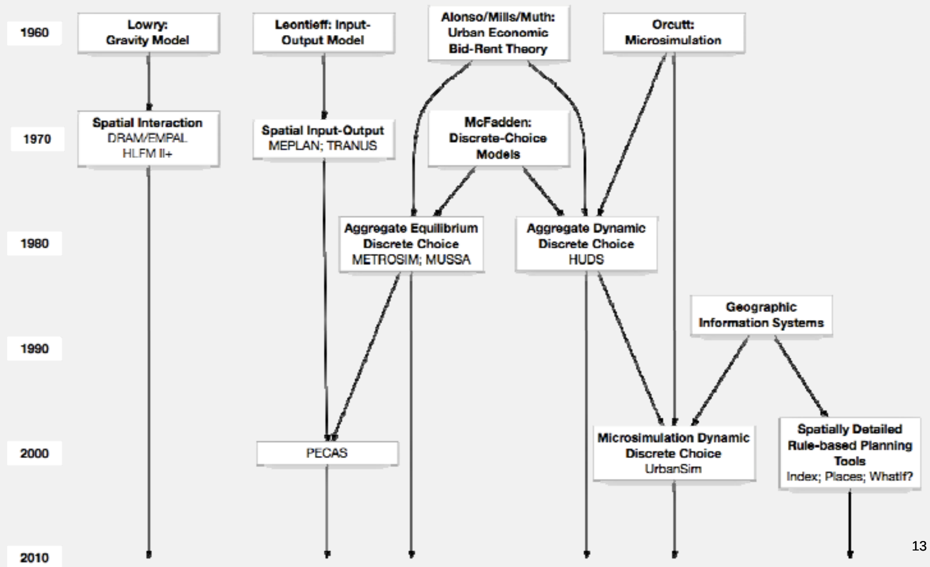
## The Evolving Role of Land Use Forecasting: Evolution of Land Use Model Frameworks

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## Pre-1990 Approaches to Land Use Modeling

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## Overview of Pre-1990 Models

- Aggregate
  - Large zones (30 - 200 to represent region)
  - Aggregated jobs and households into small number of types
- Equilibrium
  - Iterative solution to achieve static equilibrium
  - No representation of chronological time or path-dependence
- Manual calibration
- Examples for more detailed review:
  - Spatial-Interaction (gravity) models (PLUM, DRAM/EMPAL)
  - Spatial Input-Output models (MEPLAN, TRANUS)





## DRAM/EMPAL

- Developed by Stephen H. Putman, University of Pennsylvania
- Derived from Lowry Gravity model; spatial interaction model
- Uses travel times; allows interaction with travel models
- First model in wide use in U.S. (15+ MPOs at one point)

## DRAM/EMPAL: Data Inputs

- DRAM
  - Employment by type (4-5 sectors)
  - Households by income quartile
  - Vacant developable land
  - Percent of land already developed
  - Regional matrix converting employment by industry to households by income quartile
  - Zonal travel impedance matrix
- EMPAL
  - Employment by type in previous period (5 year)
  - Total land area
  - Total households in previous period
  - Zonal travel impedance matrix





## DRAM/EMPAL: Application

- Calibration done using Calib
- Estimates K-factors, or residuals
- Residuals typically used during forecasting
- Forecasts can be constrained by zone:
  - Absolute minimum
  - Absolute maximum
  - Specific quantity
- Attractiveness of zone can be modified by changing value of K-factor

## DRAM/EMPAL: Limitations

- Concerns about accuracy of forecasts
- Need to rely on K-factors
- Lack of behavioral content
- High level of aggregation
  - Population and employment categories
  - Zones (inconsistent with travel model zones)
- No accounting of built space
- Absence of land market, prices
- Cross-sectional equilibrium: everyone moves





## TRANUS and MEPLAN

- TRANUS and MEPLAN are close substitutes
- MEPLAN – Marcial Eschenique
- TRANUS – Tomas de la Barra
- Both include:
  - Spatial input-output model
  - Capacity to model commodity flows
  - Include markets for land, floorspace and labor
  - Include travel model
- Both widely used outside U.S.

## TRANUS and MEPLAN: Data Inputs

- Land use by category
- Floorspace by category
- Population by category
- Employment by category
- Land prices by land use category
- Floorspace prices by floorspace category
- Input-output economic structure
- Exogenous forecasts of economic output
- Travel networks
- Policies such as pricing, zoning, taxes
- Exogenous production and consumption by zone and sector
- Exports and imports by zone and sector
- Value added and unit price by zone and sector





## TRANUS and MEPLAN

- Calibration is heuristic; not statistical
- Differences:
  - Software implementation and platforms
  - Traffic assignment methods
  - Price
- U.S. application has been tested in Sacramento (both), and Baltimore (TRANUS), and in statewide Oregon TLUMIP Gen 1 model

# TRANUS and MEPLAN: Limitations

- Structure and level of aggregation of models better suited to statewide rather than intra-urban modeling
- Aggregate zonal system (30+ zones) inadequate for many urban applications
- Calibration is difficult and lacks a statistical basis
- High data requirements, though these can be simplified at the cost of model realism
- Cross-sectional equilibrium approach; everyone moves
- Input-Output models based on make-use technical coefficients at the national level that need to be updated and may not be appropriate for local applications.





# Requiem for Large-Scale Models: 7 Deadly Sins

- Doug Lee (1973), Requiem for Large-Scale Models, Journal of the American Planning Association.
- ‘7 Deadly Sins’ of urban models at the time:
  - Hypercomprehensiveness: trying to reflect too much real-world complexity, and to solve too many problems at the same time
  - Grossness: level of detail was too coarse to be of much use to policymakers
  - Hungriness: ‘excessive’ data requirements
  - Wrongheadedness: e.g. imputing individual behavior from aggregate data; limitations and constraints that are not well documented
  - Complicatedness: interactions among components compound complexity
  - Mechanicalness: order dependency, iterative convergence are unrealistic
  - Expensiveness: $$$

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## Requiem for Large-Scale 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 (and no simpler!)

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## Post-1990 Approaches to Land Use Modeling

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# 1995 TMIP Land Use Modeling Conference, Dallas

- Practitioners, Academics, Consultants to Assess the State of the Practice
- Echoed Lee's critiques:
  - data limitations
  - excessive use of resources, effort, and time
  - models that are too complicated and inaccessible,
  - insufficient theory and behavioral content,
  - inadequate testing and validation
- Emphasized in new model development:
  - Discrete choice framework
  - Disaggregate modeling rather than aggregate
  - Dynamic over static approaches
  - Modular model systems

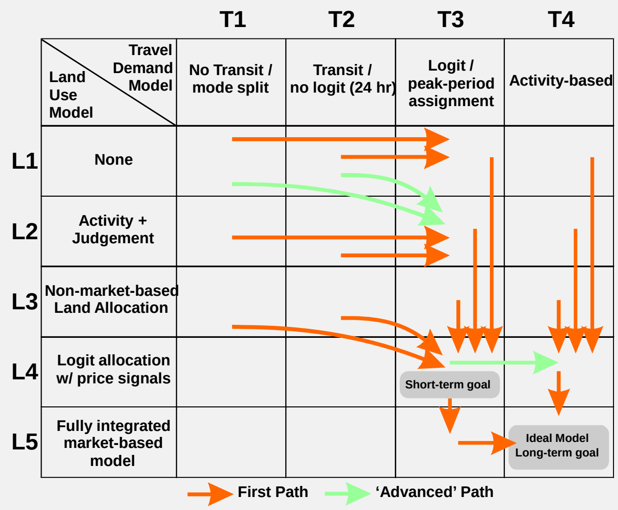




# Post 1990 Trend Towards Dynamic Microsimulation

- As transportation modeling has been moving towards activity-based travel, the need for spatial and individual-level microsimulation of land use has also increased.
- Similar motivations for microsimulation apply in both land use and travel models:
  - More realistic representation of actual behavior
  - More understandable since behavior of models mimics those of real persons
  - Computational efficiency from microsimulation as complexity of aggregate models increased
  - Easier to represent dynamics and path-dependence
  - But arguably more difficult to calibrate and validate
- Operational example is UrbanSim, developed from 1996
- ILUTE (Miller and Salvini) reflects similar design goals
- Main desirable properties in dynamic microsimulation models developed in Miller, Krieger and Hunt, 1998

## Post 1990 Trend Towards Dynamic Microsimulation






*Source: Miller, Kriger and Hunt 1998*



## The 'Ideal' Model (Miller, Kriger and Hunt 1998)

- **Physical System**
  - Time: Dynamic evolution of the system state in one-year time steps. System state generally not in equilibrium. Interactions between long-run and short-run processes are "properly" accounted for.
  - Land: The basic unit of land is the individual lot.
  - Building Stock: Building stock is explicitly represented. Each lot has a certain amount of floor space, characterized by type, price, etc.
  - Transportation Networks: Full, multimodal representation of the transportation system used to move both people and goods.
  - Services: Sufficient representation of other services for the purpose of modeling land development decisions.

## The ‘Ideal’ Model (Miller, Kriger and Hunt 1998)

- **Decisionmakers**
  - Persons and Households: Both persons and households are explicitly maintained (with appropriate "mappings" between the two entities) in sufficient detail to model the various processes of interest.
  - Firms: Explicitly represented.
  - Public Authorities: Represented within the model to the extent they generate purely endogenous effects (employers of workers; demander / supplier of services; etc.). Will remain represented largely by exogenous inputs to the model.





## The ‘Ideal’ Model (Miller, Kriger and Hunt 1998)

- **Processes**
  - Markets: Land development, residential housing, commercial floor space and labor all function within economic markets which possess demand and supply components and price signals which mediate between demand and supply. These economic markets must be explicitly modeled if their behavior over time is to be captured properly.
  - Land Developers: Represented in the model explicitly as agents developing individual properties or, implicitly, as a collective entity that produces new housing supply and commercial floor space and allocates it to parcels.
  - Demographics: Demographic processes should be modeled endogenously so as to ensure that the distribution of population attributes (personal and household) are representative at each point of time being modeled and are sufficiently detailed to support the behavioral decision models being used.

## The ‘Ideal’ Model (Miller, Kriger and Hunt 1998)

- **Processes**
  - Regional Economics: Essential components of urban production / consumption processes should be modeled endogenously. The model should also be sensitive to macro exogenous factors such as interest rates, national migration policies, etc.
  - Activity / Travel: The travel demand component of the integrated model should be activity-based and sufficiently disaggregated so as to properly capture trip-makers' responses to a full range of transportation policies, including ITS and TDM.
  - Automobile Holdings: Household auto holdings (number of vehicles, by type) should be endogenously determined within the model.





## Variation in Context: Maybe No Single ‘Ideal’ Model?

- Size of metropolitan area
- Economic conditions
- Topographical or environmental constraints
- Range of land use and growth management policies
- Transportation infrastructure and range of transportation policies
- Governmental structure
- Nature of policy questions
- In general: shift to more strategic and tactical use of models for supporting policy analysis and negotiation

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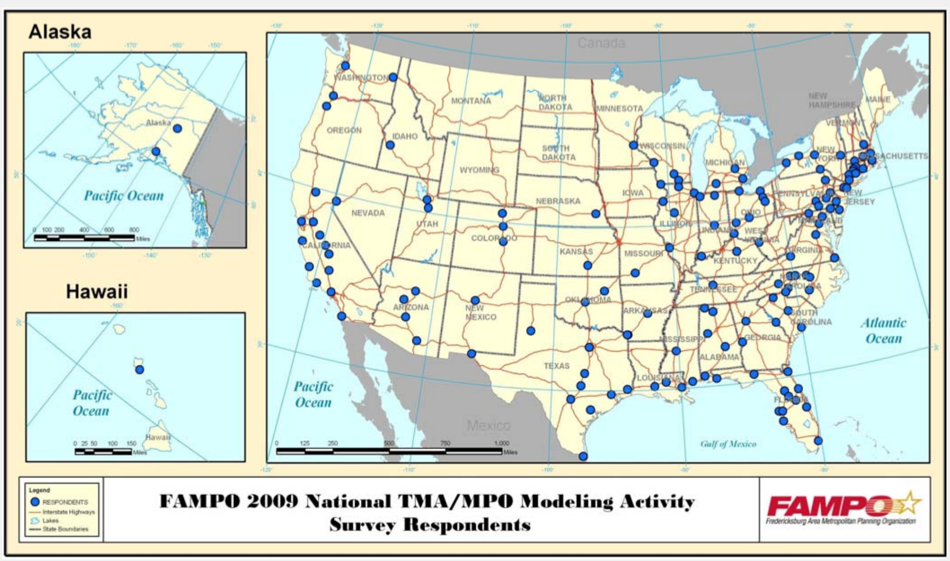
## State of the Practice: Circa 2010



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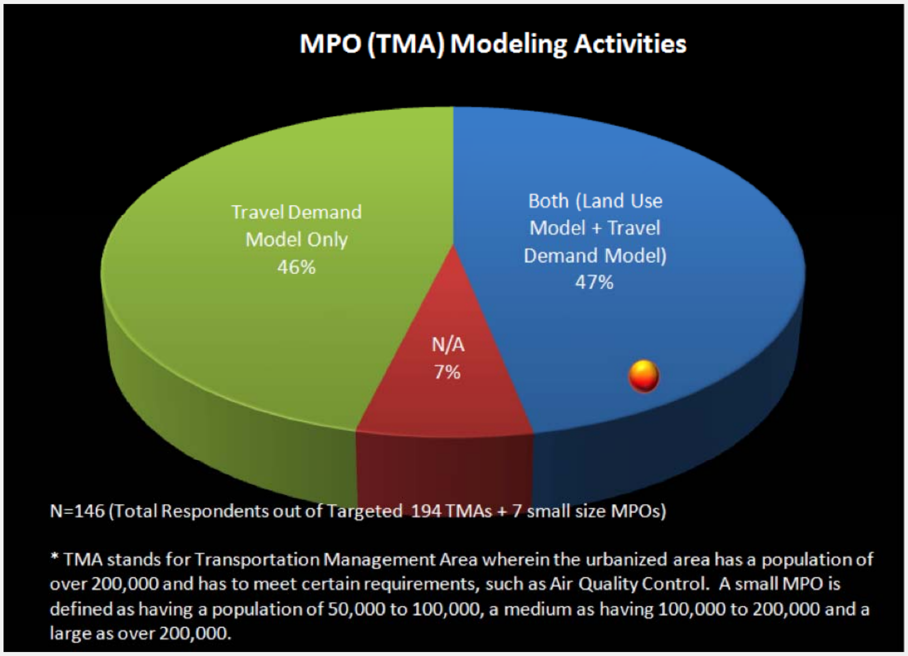


Source: 2009 MPO Survey by FAMPO

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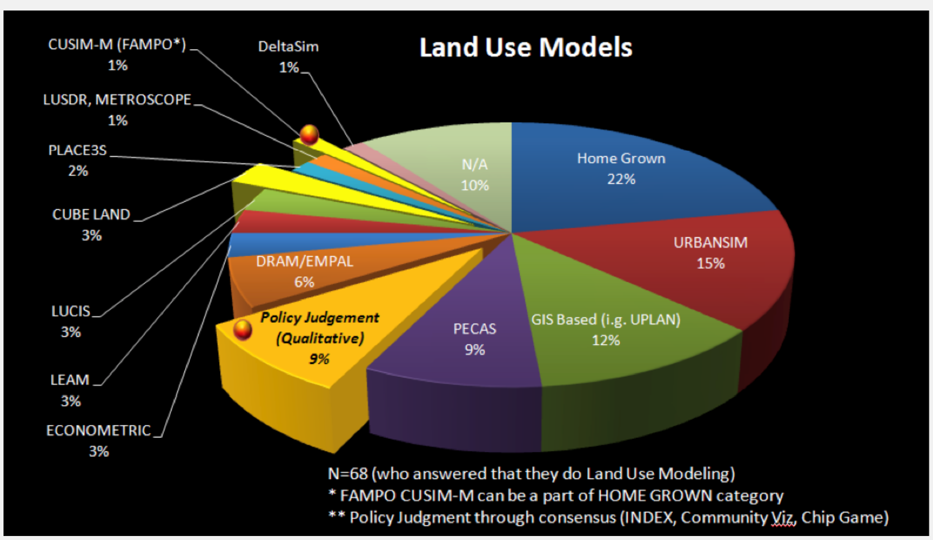


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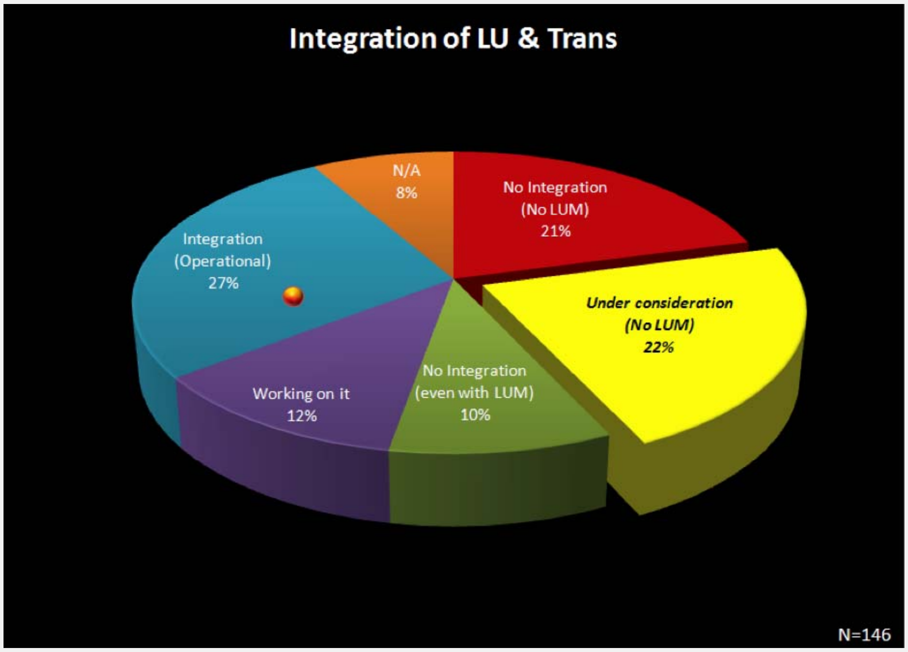


Source: 2009 MPO Survey by FAMPO

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## The State of the Practice: Survey of MPOs in 2010

### Currently Using

| | Used in last projection series | Used in last RTP update |
|---|---|---|
| PECAS | 1 | 0 |
| OPUS/UrbanSim | 3 | 4 |
| CUBE Land | 0 | 0 |
| Places3 | 0 | 0 |
| CommunityViz | 0 | 0 |
| DRAM/EMPAL | 5 | 3 |
| Home Grown | 6 | 5 |
| Other | 0 | 1 |

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# Evaluating Models: Model Validity

- Is the model structure theoretically sound?
- 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
- Does it integrate well with the regional travel model system?

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## 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?



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## Design of New Models Should...

- Start by identifying the questions:
  - What is the policy context?
  - What policies are under consideration?
  - What sensitivities would the model need to be useful in evaluating these policies?
- What behavioral/theoretical basis is needed?
- What level of detail is needed?

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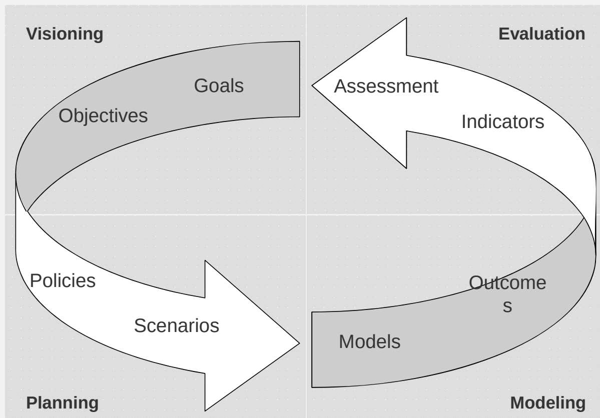
# Recommended Use of Models in Planning Context

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# Recommended Model Development Process

1. Assess the institutional, political and technical context
2. Assess stakeholders, value conflicts and public policy objectives
3. Develop measurable benchmarks for objectives
4. Inventory policies to be tested
5. Map policy inputs to outcomes
6. Assess model requirements
7. Prepare input data
8. Develop model specification
9. Estimate model parameters
10. Calibrate model system
11. Validate model system
12. Operational Use: Analyze Alternative Scenarios

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## Recommended Model Development Process

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- Most applications gloss over the first six steps and jump in with a rudimentary model requirement assessment that may be very short-sighted (the immediate deadline) or too ambitious (the perfect model to solve any current and eventual need)





## Recommended Model Development Process

**7. Prepare input data**

- This is the step that takes the longest
  - Could take 1-2 years for parcel level data for a multi-county region
    - Substantial effort for cleaning data and reconciling employment and census data
    - But, data has multiple uses and can serve as a baseline for monitoring
  - Could take as little as a couple of weeks to one month using existing zonal data
    - TAZ-level travel model inputs, Travel model skims
    - But, resulting model will be very aggregate and simplified
- Recommendation: Incremental Development
  - Could begin with a simplified zonal model to begin rapidly
  - Could develop a parcel-level version in parallel, over longer time period
  - Could also consider a two-level model system: zone (or submarket), then parcel
  - Could also begin with a subarea parcel model for a corridor or study area

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## Recommended Model Development Process

8. Develop model specification
9. Estimate model parameters

- Steps 8 and 9 are usually iterative: test alternative model specifications by estimating parameters using statistical methods (regression, discrete choice) and assessing goodness of fit
- Some model systems (scenario planning tools, Spatial Input-Output, Spatial Interaction) do not typically involve estimating parameters using standard statistical methods
  - These approaches either use assumed parameters,
  - or they involve heuristic calibration (trial and error experimentation)
- Statistical estimation on local data is more likely to produce a useful model in a local context, than making strong assumptions about those parameters

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## Recommended Model Development Process

1. Calibrate model system
2. Validate model system

- Calibration usually implies adjusting the constants in a model in order to better match calibration targets: total quantities or market shares
- Validation implies looking at the overall capability of the model system to produce valid results, using a variety of measures
- In transportation modeling this is usually done using the base year - the same year as the estimation is done on
- But this does not provide any information about how well the model predicts over time
- Longitudinal calibration and validation are much more likely to produce useful models for long-term forecasting and scenario analysis
- Unfortunately this is rarely done in land use (or transportation) modeling

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## Model Development Staffing

- Staffing support varies substantially among MPOs using land use models
- Large MPOs may have specialized staff for:
  - Tracking development projects and building permit activity; possibly market conditions such as rents and vacancy rates
  - Monitoring and analyzing employment location patterns and trends, cleaning geocoding
  - Monitoring and managing parcel-level data, and land use plans from cities
  - Providing GIS support for geodatabase management, customized queries, reporting
  - A dedicated modeler who can estimate and run a land use model, and interact with the travel modeling team
- Smaller MPOs and other planning agencies may have...
  - A single planner who is doing some subset of the above, and many other things
- Models need to be available that are usable in either kind of environment





## Thank You!
## Questions and Discussion