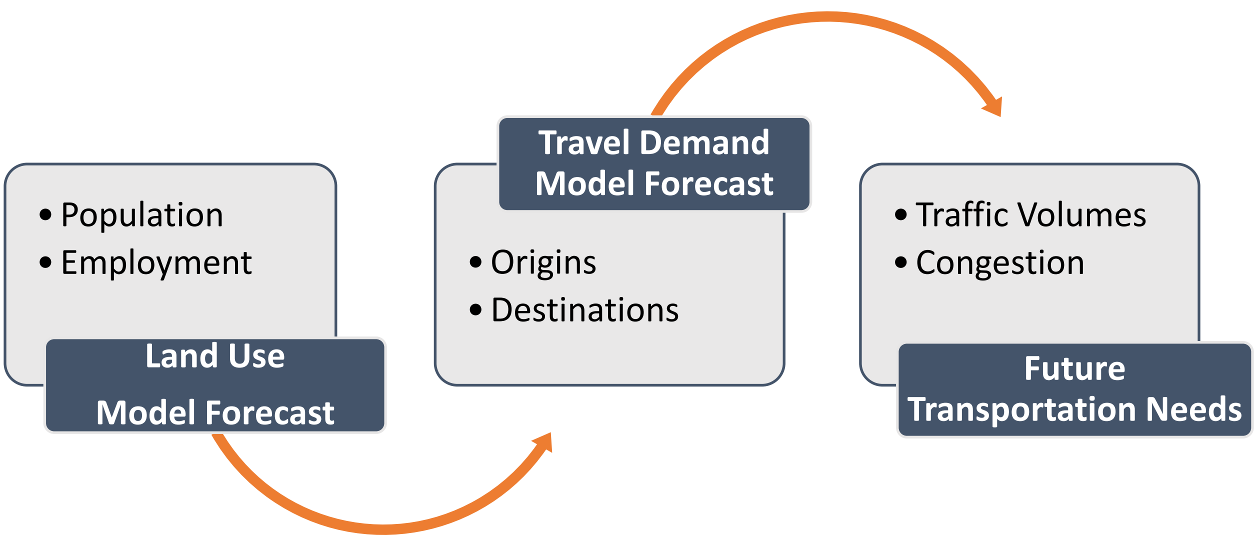
Excerpt from Appendix H: 2040 Connections MTP

Land Use Forecasting Methods *April 2020*

Introduction

Federal transportation legislation mandates a planning process that links transportation with land use, and MRCOG has responded to this call with a commitment to integrated planning. As such, the Mid-Region Metropolitan Planning Organization (MRMPO) operates a locally customized implementation of the UrbanSim land use model to forecast the spatial distribution of people and jobs moving into and within the region. The UrbanSim land use model is integrated with the Cube travel demand model which means that the modeling framework allows land use decisions to impact future congestion, which in turn impacts future land use. The socioeconomic forecast serves as the primary input to the travel demand model in order to forecast future travel demand, which then informs decisions related to future transportation infrastructure needs. This section describes how land use is forecast and the integration of the land use model and the travel demand model.

Figure H-1: Land Use and Travel Demand Modeling Framework



UrbanSim Overview

UrbanSim is a microsimulation land use model designed for analyzing the potential effects of land use policies and infrastructure investments on the development and character of the region. The modeling system relies upon a data-driven, transparent, and behaviorally-focused methodology that is designed to attempt to reflect the interdependencies in dynamic urban systems, focusing on the real estate market and the transportation system, and on the effects of individual and combinations of interventions on patterns of development, travel demand, and household and job location. UrbanSim has become the operational modeling approach for a variety of metropolitan areas in the United States and abroad, and is actively used by planning organizations in Austin, Chicago, Denver, Detroit, Honolulu, Phoenix, Minneapolis, Salt Lake City, San Diego, San Francisco, Eugene-Springfield, Seattle, and Paris among others.

UrbanSim works by simulating the interactions among households, businesses, and developers within real estate markets. By modeling the real-world trade-offs between housing costs, accessibility, and various other amenities, UrbanSim predicts households' location choices. UrbanSim also replicates local employment dynamics, including a firms' location choices. Furthermore, the model simulates developers' choices of what kind of buildings to build, where, and when, and whether to redevelop existing properties. Land use policies constrain what developers can build, and transportation plans modify accessibility patterns, which influence the attractiveness of different locations for households and firms. These dynamics influence prices and rents and the market conditions for new development or redevelopment.

UrbanSim simulates changes by single year increments, and the results of one year provide the starting point for the next simulation year. This method closely replicates the way that urban areas evolve, year over year, with mismatches between the supply and demand of housing and jobs. Typically, metropolitan areas see only a small fraction of the housing stock added in a given year. Development of real estate proceeds slowly in response to rapid changes in demand, leading to swings in vacancy rates and prices, and to the commonly observed booms and busts in real estate cycles.

Key conceptual underpinnings of UrbanSim include:

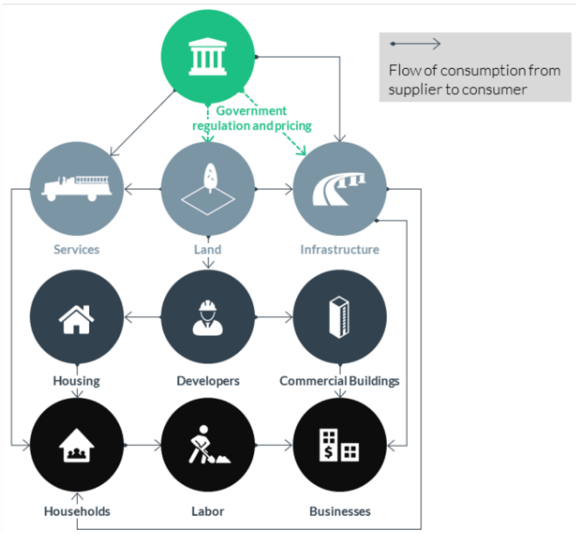
- Representation of individual decisions made by households, employers, people and jobs.
- Representation of the supply and characteristics of land and of real estate development.
- A dynamic perspective of time, with the simulation reacting to changing conditions year to year.
- The use of real estate markets as a central organizing focus, with consumer choices and supplier choices explicitly represented, as well as the resulting effects on real estate prices. The relationship of households or employers to real estate tied to specific locations provides a simple accounting of space and it's use.
- The use of Multinomial Logit Models to represent the choices made by households, employers and developers (principally location choices).
- Integration of the urban simulation system with existing transportation model systems, to obtain information used to compute accessibilities and their influence on location choices, and to provide the inputs to the travel models.

Model System Design

In the UrbanSim model, buildings are located on parcels that have particular characteristics such as value, land use, and developable area. Local municipalities set policies that regulate the use of land, through the imposition of zoning or through pricing policies such as development impact fees. Municipalities also build infrastructure, including transportation infrastructure, which interacts with the distribution of activities to generate patterns of accessibility at different locations that in turn influence the attractiveness of these sites for different consumers. Households have particular characteristics that may influence their preferences and demands for housing of different types at different locations.

Businesses also have preferences that vary by industry and size of business (number of employees) for alternative building types and locations.

Figure H-2: Households and Employer Interactions within Real Estate Markets.



UrbanSim predicts the evolution of households, employers and their characteristics over time, using annual steps to predict the movement and location choices, the development activities of developers, and the impacts of governmental policies and infrastructure choices. The land use model is interfaced with MRMPO's travel model system to deal with the interactions of land use and transportation. Access to opportunities, such as employment or shopping, are measured by the travel time or cost of accessing these opportunities via all available modes of travel. See the travel model integration section for details.

MRMPO uses exogenous regional employment and population forecasts as control totals, meaning that these are inputs that are not predicted directly by UrbanSim or MRMPO. The University of New Mexico Bureau of Business and Economic Research (UNM-BBER) uses a macroeconomic model to predict short term future employment by sector which is supplemented by MRMPO using a long-term employment forecast from Regional Economics Modelling Inc. (REMI) to create a regional employment control total. The University of New Mexico Geospatial Population Studies (UNM GPS) develops county level population projections using the cohort component method which relies on predicting births, deaths and migration that is used as a population control total.

UrbanSim Inputs

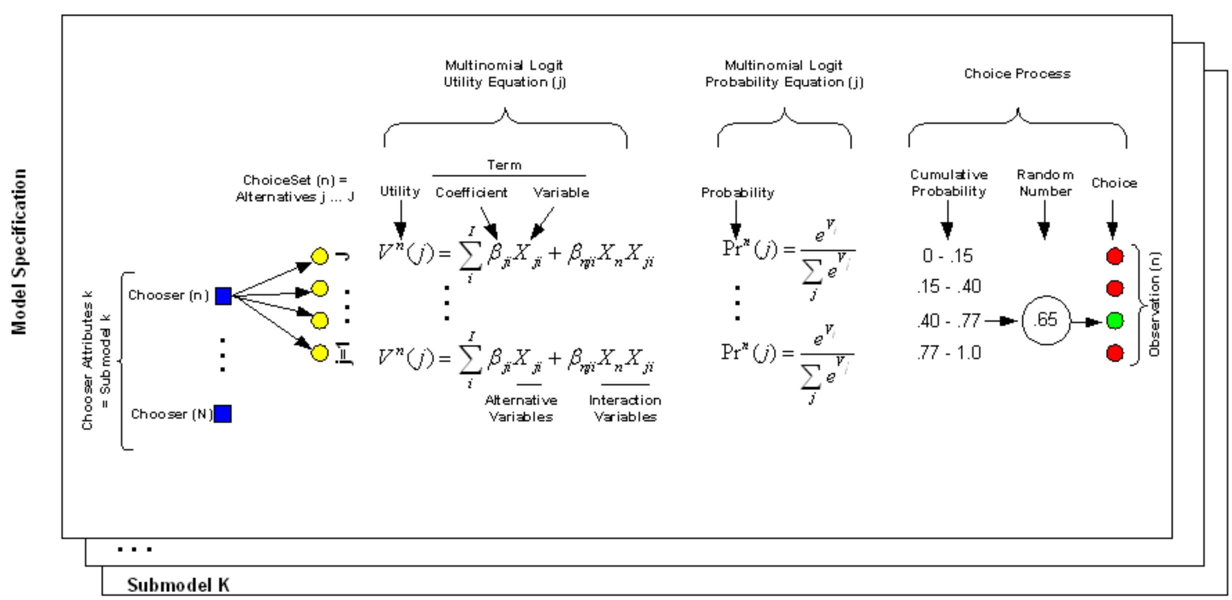
- Employment data from New Mexico Department of Workforce Solutions and InfoGroup
- Household data merged from multiple U.S. Census sources and ESRI Business Analyst Online
- Municipal, County, Tribal and State land use plans and regulations such as zoning
- Undevelopable land, Federal land, Tribal land, and State land boundaries
- Congested travel times from the Cube travel demand model
- Parcel database supplemented with local data pertaining to land use, housing units, nonresidential square footage, year built, land value, and improvement value. Sources include

County Assessors, local planning Geographic Information Systems (GIS) databases, CoStar, Metrostudy, and building permits issued for new construction.
- Average construction costs from RSMeans

Discrete Choice Models

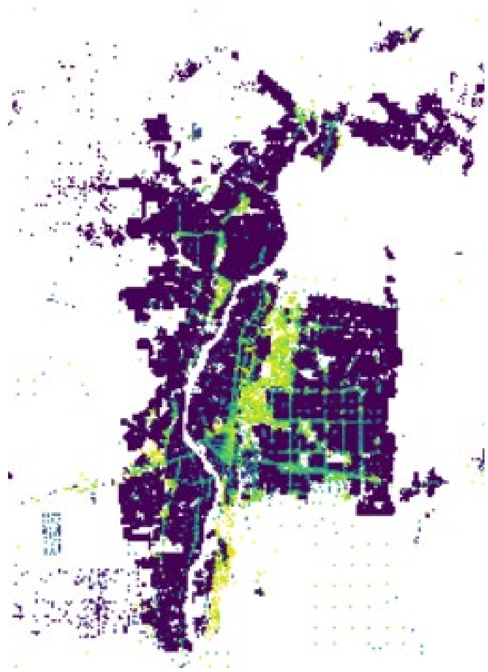
UrbanSim makes extensive use of discrete choice models where individual households and employers choose buildings. First, multinomial logit models are estimated based on the variables that have proven to be statistically significant in explaining past behavior. For example, households that moved to the region in the last 5 years are evaluated based on the census tracts that they chose to move to. The estimated model then generates a probability that a particular household (based on income and other characteristics) will pick a particular housing unit (of different sizes, prices and other characteristics). In order to predict choices given the predicted probabilities, the choice algorithm uses a sampling approach. As illustrated in the figure below, a choice outcome can be selected by sampling a random number from the uniform distribution in the range 0 to 1, and comparing this random draw to the cumulative probabilities of the alternative housing units. Whichever alternative the sampled random number falls within is the alternative that is selected as the 'chosen' one. This algorithm has the property that it preserves in the distribution of choice outcomes a close approximation of the original probability distribution, especially as the sample size of choosers becomes larger.

Figure H-3: UrbanSim Choice Models



The figure below shows an example of the probability of an employer selecting a particular parcel in the Albuquerque Metropolitan area, yellow indicates areas that are more attractive for employers.

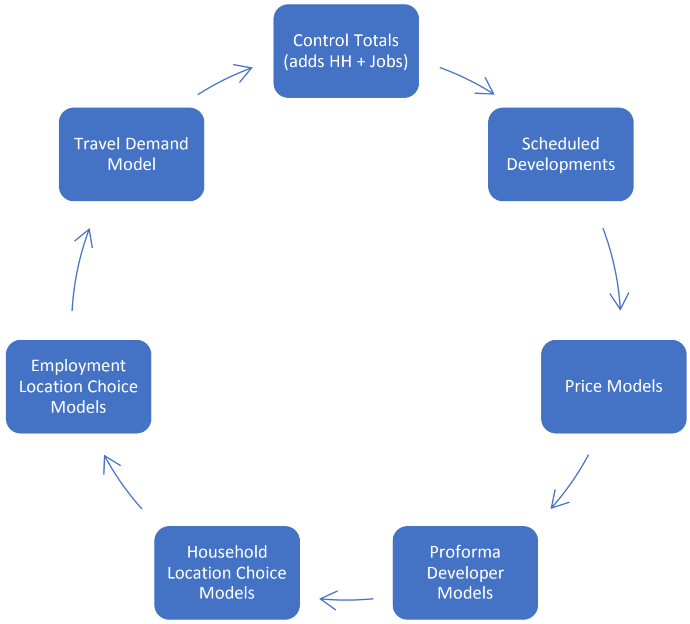
Figure H-4: Sample probability of a manufacturing firm locating on a particular parcel (yellow is high, purple is low)



Model Steps

Each simulation year follows the steps seen in Figure x. First, the control totals developed externally by UNM and REMI determine how many new households and jobs are introduced to the region. Next, the known scheduled developments are built. Next, the Price Models update real estate prices followed by the proforma and developer steps calculating costs of potential sites and then building new buildings that are profitable. Next, the Household and Employment Location Models place households and jobs into empty buildings based on the predicted attractiveness of each site. Finally, because the spatial allocation of people and jobs has been altered, the Travel Model is updated and calculates new congested travel times. The updated travel times will affect the next year's prices and location choices.

Figure H-5: Model steps in each simulation year



Developer Models

- **Scheduled Developments:** Known development projects that are either currently under construction or set to begin building in the near term are added to the simulation in the appropriate year. This allows areas of current growth to be seeded with real projects and updates the base year data from 2016 to current conditions.
- **Proforma:** Computes the costs and revenues of feasible development projects allowed by zoning and creates new buildings. Costs include: construction costs, demolition costs (if parcel is not vacant), financing costs, and parking construction costs. Using the modelled prices from the Price Models to estimate potential revenue of different developments, the most profitable development projects are built in each simulation year.

Price Models (Ordinary Least Squares Regression)

- **Commercial Price Models**: These models are segmented by office, retail, and industrial. Important estimation variables include: accessibility to workers (based on travel model outputs), year built, proximity to freeway exits, size of parcel or building, within 'key center', accessibility to other employers (clustering effect).
- **Residential Price Model**: Important estimation variables include: accessibility to jobs (based on travel model outputs), proximity to industrial sites (negative coefficient), income level of neighborhood, access to transit, year built, and access to retail or food services.

Location Choice Models (Multinomial Logit)

- **Employment Location Choice Models**: These models are segmented by employment sector. Important estimation variables include: commercial rent/price per square foot, size of parcel or building, type of commercial building, year built, accessibility to other employers (clustering effect) and accessibility to workers.

- **Household Location Choice Models**: These models are segmented by income. Important estimation variables include: rent or price per residential unit, unit square feet, year built, accessibility to jobs (based on travel model outputs), access to transit, access to retail or food services, average household size of neighborhood, and income level of neighborhood.

Integrated Modelling Approach

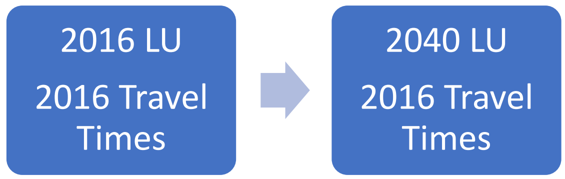
An integrated modelling approach that combines land use and travel demand is improves the ability to reflect future conditions that are representative of the dependencies between housing and employment choices and congestion.

Without the travel demand model, the land use model uses only one set of travel times throughout the whole simulation, meaning that regional growth does not affect travel times and congestion does not affect future growth. In contrast, when the land use model runs interactively with the travel demand model, the travel times get updated every time the travel demand model runs. The interaction between the two models occurs every 5 years starting in the simulation year 2020 and concluding in 2040. With each iteration of the travel demand model, land use development patterns are modified because travel time is a factor when deciding where to build future development.

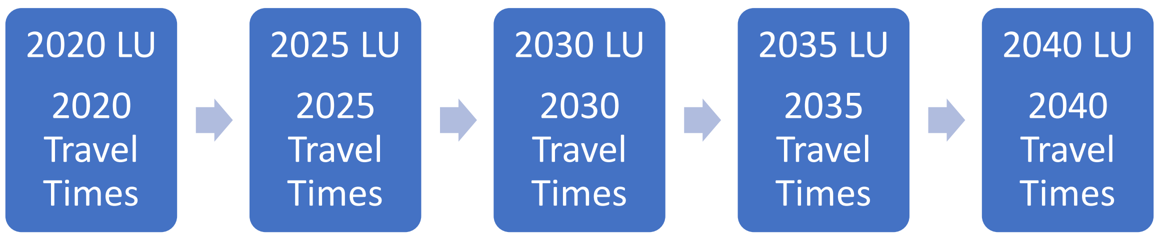
The following picture illustrates the differences between a traditional and an integrated model approach to predicting future land use.

Figure H-6: Traditional Approach vs. Integrated Approach to Modelling Land Use

Traditional Approach



Integrated Approach



The table below shows the differences in expected growth between the traditional modeling approach and the integrated approach. The travel demand model results are based on a "no build scenario", in which the base 2016 roadway network remains static in order to create a true comparison between the two runs.

Table H-1: Forecast Differences by County when Applying an Integrated Model Approach

County	Jobs	Households
Bernalillo	0.13%	1.45%
Sandoval	-1.25%	-3.60%
Valencia	-2.99%	-4.97%
Torrance	-4.74%	-7.35%

All counties except Bernalillo County show a declining share of growth within an integrated modeling framework. This reflects the decreased access to key destinations from surrounding counties when future congested travel times are introduced. As congestion levels rise, Valencia, Sandoval and Torrance become less attractive for future development given that many trip purposes and in particular work commutes are destined for Bernalillo County.

Integration between the land use and travel demand models is a more realistic approach to forecasting. By allowing the models to interact we are able to better simulate real world decision-making as we know that issues of congestion and travel times to common destinations often play a role in where households and employers chose to locate.

Assumptions and Limitations of UrbanSim

UrbanSim is a model system, and models are abstractions, or simplifications, of reality. Only a small subset of the real world is reflected in the model system, as needed to address the kinds of uses outlined above. Like any model, or analytical method, that attempts to examine the potential effects of an action on one or more outcomes, there are limitations to be aware of.

- *Boundary effects are ignored.* Interactions with adjacent metropolitan areas pose modeling difficulties due to boundary effects. For example, MRMPO does not model interactions with Santa Fe even though residents of the Mid-Region work in Santa Fe or vice-versa.

- *Zoning regulations are assumed to be binding constraints on the actions of developers.* Parcels are constrained by their zoned densities with the exception of the known scheduled developments which are always built, and approved master planned areas which are updated to reflect the intended uses and densities shown in the plans.

- *UrbanSim is a regional land use model and results should not be used at a parcel level.* While UrbanSim is a microsimulation model, results are intended to be aggregated to larger geographies such as DASZs in order to avoid the inaccuracy inherent at the parcel level.

- *Behavioral patterns are assumed to be relatively stable over time.* The UrbanSim model assumes that behavioral patterns will not change dramatically over time. Models are estimated using observed data, and the parameters reflect a certain range of conditions observed in the data. If conditions were to change dramatically, such as fuel prices tripling and continuing to increase, it is probably the case that fundamental changes in consumption behavior, such as vehicle ownership and use, would result.