The SILO Land Use Model[1]

The Simple Integrated Land Use Orchestrator (SILO) is meant to be implemented more easily than traditional large-scale models that require extensive model estimation. SILO was designed as a microscopic, discrete choice model. Every household, person and dwelling is treated as an individual object. All spatial decisions (household relocation and development of new dwellings) are modeled with Logit models, which are particularly powerful at representing the psychology behind decision making under uncertainty. Other decisions (such as getting married, giving birth, leaving the parental household, renovating a dwelling, etc.) are modeled with Markov models by applying transition probabilities.

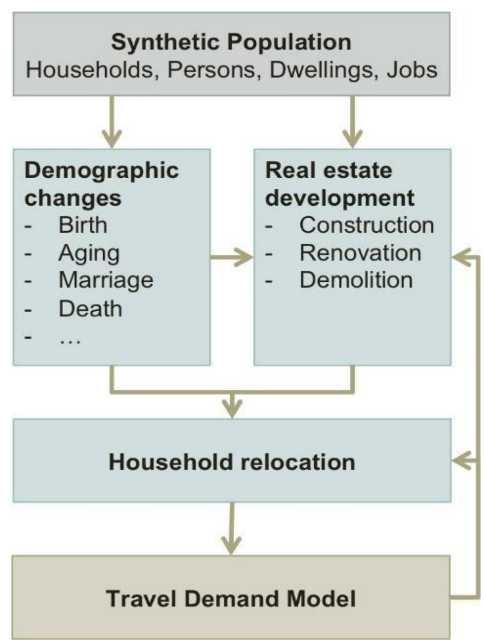
SILO is integrated with the Maryland Statewide Transportation Model (MSTM) to fully represent interactions between land use and transportation. The model is built to work with less rigorous data collection and estimation requirements than traditional large-scale land-use models. Rather than requiring costly data collection and time-consuming model estimation, SILO takes advantage of national averages where possible and transfers parameters from models that have been implemented elsewhere. The Figure below summarizes SILO's structure and key internal and external model relationships.

At the outset, a synthetic population is created for the base year 2000. Work places are created based on MSTM zonal employment data. SILO simulates events that may occur to persons, households and dwellings, as indicated below:

Household
- Relocation
- Buy or sell cars

Person
- Aging
- Leave parental household
- Marriage
- Birth of a child
- Divorce
- Death
- Find a new job
- Quit a job

Dwelling
- Construction of a new dwelling
- Renovation
- Deterioration
- Demolition
- Increase or decrease of housing price



The housing market is modeled explicitly. Vacancy rates in five dwelling types and 31 regions are used as a proxy for additional demand. If vacancy rates drop, developers will add additional dwellings if zoning permits. To find the best locations for new dwellings, developers mimic the location choice behavior of households to build the most marketable new dwellings. New dwellings are released into the housing market with a one-year delay to account

[1] Further information on model design and implementation can be found at www.silo.zone from which this description excerpts some material.

for time required for planning, approval, and construction. A hedonic price model is used to model changes in housing costs. Low vacancy rates lead to a fairly quick upward adjustment of prices, while high vacancies lead to a gradual price reduction. This reflects the observed behavior of landlords who attempt to keep prices high, even if demand is low.

From one year to the next, certain events may trigger other events. For example, if a child is born, the household will have a higher probability of moving to a larger dwelling. Within one year, however, events are modeled in random order to avoid path dependency. A random number is assigned to each event, events are sorted by this number in ascending order and executed in this sequence.

SILO is set to match observed land use changes from 2000 to 2012 (so-called back-casting) and validated in 2012. Currently, the model runs to 2040. It covers demographic changes, household relocation, and real estate changes. Workplaces and commercial floorspace are not modeled explicitly at this point but exogenously based on the financially Constrained Long-Range Transportation Plan (CLRP). In the future, an added submodel will simulate the employment side.

Modeling Constraints

SILO distinguishes between location factors that are desirable and those that are essential. Finding a place to live within someone's housing budget, for example, is considered to be an essential location factor. Having a particularly large apartment, on the other hand, is a desirable location factor. If all other location factors are excellent, a household might compromise on dwelling size.

In contrast to desirable utilities, fulfilling essential utilities is assumed to be mandatory. The three essential location factors represented by SILO include housing costs, commute travel times, and transportation costs. If one of these three utilities is 0, the utility for the entire dwelling has to be 0. This ensures that households do not move to a place that violates a budget constraint. The essential location factors and desirable location factors are described below.

Housing cost: Dwelling costs are an immediate constraint for any relocation choice. While households may exceed their housing budget temporarily, they have to live within their income in the long run. The higher the dwelling's price, the lower its utility, and utilities decline faster for low-income households than for high-income households. When the price is high enough that the share of households paying this amount for housing reaches zero, the utility becomes zero and that dwelling becomes unavailable for this household type.

Commute travel time: Travel time to work is another essential utility for household location choice. Excepting workers who regularly work from home, travel time from home to work is an important constraint when choosing a new place to live. When households consider new housing locations, the job locations of all household members are also considered. Because SILO is designed as a microsimulation, the work locations of all household members are known.

At this point, SILO doesn't explicitly represent telework. Another shortcoming worth mentioning is that the constant travel time budget seems only to be reasonable with conventional modes of transportation. Should AVs become widely available, the value of time is expected to change substantially. AV travel may lessen the burden of commuting and thereby reduce this constraint in housing location. In this PRESTO application, the importance of travel time is reduced in the model to capture this aspect of AV usage.

Transportation cost: Another essential utility explicitly reflected in SILO is household expenditures. According to the Consumer Expenditure Survey of the Bureau of Labor Statistics, households spent an average of 18.2 percent of their after-tax income on transportation (fixed and variable costs) in 2000. Low-income households spent as much as 36.1 percent of their after-tax income on transportation. If transportation costs rise, those households will need to shift some expenses. While affluent households will simply reduce savings or discretionary spending to cover increased transportation costs, low-income households may struggle to cover substantially higher transportation costs.

Desirable location factors: Non-essential location factors include dwelling size and quality, accessibility to population and employment by auto and transit, low crime rates, and the quality of schools. While these location factors are desirable, one strong attribute may compensate for another weak attribute. For example, a house in the suburbs may be weak in terms of accessibility but strong in terms of size. In contrast, urban apartments tend to be weak in size but provide excellent accessibility. A strong attribute may offset a weak attribute, depending on household preferences. The NCSG also added factors that account for the reality of racial and income segregation in the region. We have the model assume that black/white segregation persists and that integration only rises with black and white income and education. Without introducing these constraints, very significant - but unrealistic- population increases occur in Baltimore City and Prince George's County,