An Assessment of Integrated Land Use/Transportation Models

Prepared for:

Southern California Association of Governments

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1. INTRODUCTION

This report documents our effort to assist the Southern California Association of Governments (SCAG) with a review and assessment of Integrated Land Use/Transportation Models. Specific tasks completed include:

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2. SCAG STAFF INTERVIEWS

As an initial step in our analysis, we conducted a series of interviews with SCAG staff in November 2006. The interviewees were selected to provide a broad perspective on the desired features of the integrated land use/transportation model. The purpose of these interviews was to identify which features should be weighted most heavily as selection criteria for the integrated model package.

The most obvious need, repeated by many interviewees, was the need for a model to test transportation strategies in relation to land use and growth projections. Beyond this basic function of an integrated model were other specific needs that are described below.

FEATURES INTENDED TO HELP SCAG MEET STATUTORY REQUIREMENTS

SCAG's staff identified a number of statutory requirements that Metropolitan Planning Organizations (MPOs) are expected to meet and that they believe an integrated model could be used for. These include:

Housing Needs Assessment and Affordability – The housing needs assessment has apparently been a contentious activity in the past and one where analytical support for the positions taken seems weak. An integrated model that could forecast housing prices would be useful for determining potential mismatches between incomes and housing costs. The model could also be used as a testing mechanism for policies that might improve affordability. This could include, for example, testing to see whether the removal of certain existing regulations would accelerate redevelopment in inner areas.

Air Quality and Emissions Calculations – The Clean Air Act of 1990 requires that different network scenarios be tested with different, and matching, land use scenarios. This is to prevent the once-common occurrence of a single auto-oriented land use scenario being used to test both freeway-oriented and transit-oriented network scenarios, with the inevitable result that the freeway scenario was found to serve auto-oriented communities better. Until now the development of the different land use scenarios has been left up to the agency involved. An integrated model would improve on this by enabling the model to develop its own forecast of changes in land use in response to the travel opportunities found in each network scenario.

Outputs in the Form of Maps and Charts – In order to make transportation plans more accessible to the public the Safe, Accountable, Flexible, Efficient Transportation Equity Act — A Legacy for Users

(SAFETEA-LU, 2005) emphasizes the use of maps, charts and other graphical displays of outputs to supplement or replace outputs in the form of tables and text. High quality graphics would also facilitate consensus-building efforts by making it easier for all parties to understand the model's forecasts. Ideally the integrated model will produce most of the needed graphics itself. Alternatively, it should produce outputs that can be readily converted into graphical displays using software available to SCAG.

Environmental Justice – The model must be able to differentiate between income groups so that each group's share of the costs and benefits of transportation investments can be determined.

OTHER DESIRABLE FEATURES

Besides the minimum statutory requirements, there are many other activities undertaken by SCAG that could benefit from an integrated model. SCAG's staff identified these features as:

Ability to Work at Different Scales – In comparing the perspectives of different potential model users, one issue that stood out was the difference in geographic scale on which analyses are being carried out. Many of the users stressed the interaction between different parts of the SCAG region and the need for the model to cover the entire area, while other users want the model to support corridor studies and a third group would like the model to predict land use changes in the vicinity of individual transit-oriented development (TOD) sites.

Ideally, a model would be able to function at all of these scales. If this is not possible, however, then the consensus is that the integrated model should focus on forecasting land uses on a region-wide scale. Other software packages will then be used to do smaller-scale analyses using the outputs from the regional model as inputs.

Ability to Forecast Development at TODs – One specific request repeated by several staff members was to have a model that would predict development at TODs. Specifically, the model should be able to predict how much development will occur in the vicinity of stations on line extensions. The model should also be able to predict the effect that offering policy incentives would have on re-development around existing stations. These predictions should reflect the experience of the existing demonstration sites.

Revenue Forecasting – Several users expressed a need for the model to help forecast changes in revenues resulting from transportation investments. This includes not only tolls and transit fares, but

also revenues from excise taxes that would vary depending on the population of each jurisdiction. In addition, changes in land values that could be subject to tax should be forecast by the model. The staff recognizes that the revenues are more likely to be indirectly obtainable through post-processing of model results than directly obtainable as explicit model outputs.

Goods Movements – Recently there has been a major effort to improve the modeling of goods movements. There are several aspects to this, including through movements for cargos from outside the region that use the ports of Los Angeles and Long Beach, goods movements that serve businesses within the region, and multi-trip goods movements such as those associated with transshipment centers. The hope is that the integrated model would support more nuanced modeling of these flows.

The desirable features listed above were mentioned by three or more staff members. Other desirable features that were mentioned include some measure of how the quality of life varies between scenarios, some measurement of open space conservation, the ability for location decisions to reflect lifestyle choices, and the ability to test "shocks" to the system such as the effects of earthquake damage, water shortages, sudden change in immigration policy, etc.

CONCERNS RAISED BY SCAG STAFF

During the course of the interviews, the staff raised a number of concerns regarding the way in which the integrated model would fit into SCAG's system. While these concerns are not model features per se, they nevertheless should be considered when planning for model implementation.

Accuracy – The most common theme in the interviews was the desire that the model produce accurate, defensible forecasts. SCAG's staff believes that if they can produce analytically correct forecasts, then consensus will follow. The staff is much more concerned about this than about having the model produce showy graphics or the ease of the model's use.

Staffing and Training – The staff expressed a healthy respect for the difficulties posed by integrated models and are aware of the need for training and experience-building. They would greatly prefer that the implementation be carried out in a way that allows expertise to be built up over a period of several years and that staff in more than one section be trained to use the model.

REGIONAL AGENCY COMMENTS

In addition to the staff at SCAG, Fehr & Peers interviewed staff with Metro and the Riverside County Transportation Commission (RCTC). The staff interviewed was generally supportive of an integrated land use/transportation model, particularly as it might be applied to the land use forecasting process. Based on our conversations, it appears that the main products that the member agencies use from SCAG are the regional land use forecasts, which then serve as the basis for the travel demand models that various agencies employ. Given their use of land use forecasts, many of the comments below from the regional agencies relate to the land use forecasts:

Consistency in Land Use Forecasts – One of the concerns raised by Metro is the consistency between various iterations of the land use forecasts. They have sometimes experienced large-scale changes in the land use forecasts that affect their corridor study results. These inconsistencies can be traced to a second concern, which is the level of member agency input into the regional forecasts.

Member Agency Input – There is a perception among the regional agencies that SCAG does a good job of incorporating input from the member agencies into the regional land use forecasting process. However, it is possible that SCAG may be too accommodating to the member agencies by often allowing them to dictate local land use. They both thought that a more rigorous analytical tool could allow SCAG to "push back" at local agencies that might be overly aggressive in promoting localized land use forecasts at odds with other areas of the region.

Open Process – Both of the regional agencies indicated that they would like to be able to understand the integrated model, should one be developed. They do not want the model to be developed as a "black box" where much of the detailed information is unavailable.

Equal Level of Detail – RCTC staff indicated that they would want the model to provide the same or equivalent level of detail in Riverside County as compared to other counties in the SCAG region.

Both Metro and RCTC staff indicated that they would be very supportive of an integrated model and would encourage SCAG to develop a tool.

STAFF INTERVIEWED

The following people were interviewed:

Information Services Department

- Keith Killough, Director of Information Services
- Huasha Liu, Manager of Data & Monitoring, ISD
- Ping Chang, Program Manager, Performance Assessment and Monitoring, ISD
- Guoxiong Huang, Modeling Specialist
- Mike Ainsworth, Special Projects & Monitoring
- Deng Bang Lee, Manager of Modeling Division

Planning and Policy Department

- Hasan Ikhrata, Director of Planning and Policy
- Naresh Amatya, Program Manager of System Planning, P&P
- Mark Butala, Program Manager, Community Development Division, P&P
- Arnold Sherwood, SCAG Staff, P&P
- Jacob Lieb, Program Manager, Comprehensive Plan of Environmental Planning Division, P&P
- Frank Hao Wen, Program Manger of Forecast, P&P
- Danny Wu, Program Manager, Goods Movement, P&P
- Mike Jones, Goods Movement, P&P

SCAG Executive Management

- Mark Pisano, Executive Director
- James Gosnell, Deputy Executive Director

Partner Agencies

- Chaushie Chu, Metro
- Fulan Guan, Metro
- Robert Farley, Metro
- Shirley Medina, RCTC

3. LONG LIST AND SHORT LIST

INTRODUCTION

Based on a review of existing studies, we identified a "Long List" of integrated land use/transportation models that might be used by SCAG. The purpose of the Long List is to identify integrated land use/transportation software packages and determine whether or not they have sufficient potential to meet SCAG's needs to justify more in-depth evaluation. Previous studies have described the various features of these packages, and it is not our intention to duplicate these efforts. It is sufficient to determine whether or not the package has any "fatal flaws" that should effectively eliminate it from further consideration for the particular use that SCAG intends for its integrated model. This evaluation covers only the model's suitability for SCAG's intended application; the models' suitability for other applications was not evaluated.

LONG LIST

Evaluation Process

Packages whose names are shown in **green** font have the potential to fulfill most or all of SCAG's requirements and are listed first. Those shown in **amber** font could fulfill some but not all of SCAG's requirements and so could serve as an intermediate step towards creating an integrated model, should such a step be desired. These second-tier packages are listed second. Packages whose names are shown in **red** font are considered to have fatal flaws that eliminate them from further consideration for SCAG's application. They are listed last.

Models Reviewed

PECAS: This package consists of two parts, a spatial input-output model and a land development model. The spatial input-output model is a nested logit model of three types of choice. The highest level involves the choice of location for activities. The second level covers decisions on how much to produce or consume of goods, services, labor, and floor space, given the location. The third level covers choices about where to buy and sell given the location and what each actor produces and consumes. The third level generates origin-destination (O-D) matrices of the movement of goods and people, so it resembles the trip generation and distribution parts of a conventional travel demand model. These matrices can be used as inputs into a traffic assignment to get the impedances for the next period.

The second part of PECAS is the land development model. The exchanges in the third level produce relative scarcities which change prices, suppress demand and stimulate supply for the next period. Land developers look at these prices and the land available and decide what, if anything, to develop for the next period. This new space gets fed back into the location choice decisions.

This package has the advantage of dealing directly with the issues of where people and things start and where they are going. In this it resembles an activity-based model, but for unusually long periods of time, long enough for the land market to react.

> *Fatal Flaws:* None. Complexity and data requirements are concerns, but any model capable of fulfilling SCAG's requirements is likely to be complex and data-hungry.

UrbanSim: This package starts with three kinds of inputs, namely: 1) forecasts of future population, employment and economic growth, 2) a set of zoning and other policy-based constraints, and 3) a travel demand model. The population and economic forecasts generate a certain number of re-locating households and businesses, and the travel demand model produces zone-to-zone impedances. These are used as inputs for a module that forecasts relocation decisions based on the price of different types of space. Developers also react to prices in determining what new space to offer.

The outputs are the new prices for each type of space, the number of households and jobs of each type in each zone, and the amount of dwelling units and floor space of each type in each zone. The prices get fed into the relocation decisions for the next time period, and the revised land uses get fed back into the travel demand model.

The great strength of this design is that it focuses on the behavior of key actors (households, developers, other businesses) which is readily understood and checked for reasonableness. The user acts as the government in making infrastructure and zoning decisions. An additional strength is that it produces the traditional inputs to the travel demand model (HHs and land uses by traffic analysis zones [TAZs]) and so integration with a travel demand model is straightforward.

> *Fatal Flaws:* None. Complexity and data requirements are concerns, but any model capable of fulfilling SCAG's requirements is likely to be complex and data-hungry.

METROSIM: This model is formulated upon three market equilibria, namely a labor market equilibrium with job assignment, market equilibrium, and commercial space equilibrium. The model iterates between these markets and a generalized impedance model representing the transportation system, until land use and

transportation flows attain an equilibrium state. The model has its own route assignment routine but this could be replaced by interaction with a stand-alone travel demand model, as has been done in the New York Metropolitan Region.

METROSIM forecasts a variety of development and flow indicators, e.g., travel flows, employment changes, congestion levels, new construction of residential and commercial buildings and land use change. METROSIM also provides benefit-cost ratios for transportation projects and policy interventions.

The strengths of METROSIM include its solid theoretical base in discrete choice theory, and the fact that that it is designed to work with U.S. Census data sources and assessor's parcel data. The limitations of METROSIM are primarily related to cost, and the need for the developer to participate in the application of the model to the SCAG region. License fees are currently in the $20-$30,000 range and there is a $5-$10,000 annual maintenance fee; training represents an additional one-time fee of $10,000. There is currently no GIS interface, though one could be developed for a fee (Zhao and Chung 2006, p. 27).

> *Fatal Flaws:* There are no fatal flaws, but the package is proprietary, and its developer must participate in any application. A GIS interface would need to be developed for a fee.

DELTA: This package combines an urban model that predicts the location of households, jobs, and real estate development with a regional model that predicts changes in the regional economy and migration between urban areas. The urban model has components covering the development process, household formation, economic growth, location and relocation of jobs and households in the property market, car ownership, changes in employment status (working or not) and commuting, and qualitative changes in residential areas. The regional model has components covering the pattern of production and trade, investment and disinvestment, and migration between urban areas. DELTA is designed to interact iteratively with a travel demand model.

DELTA has been used for several regions in the United Kingdom. To date, the only complete applications have been for mid-sized Metros in the UK and for Auckland, New Zealand and some European and Latin American regions. The developer reports that as of late 2006, an application for London/Southeast England (i.e., a region with a population similar to the SCAG region) is underway, but is not yet complete. The developer also reported that for a 4000-TAZ travel demand model, some customization would be required.

Fatal Flaws: Not available off-the shelf and has not been implemented in the U.S. nor for a region as large as SCAG.

MEPLAN: This package consists of three modeling modules and an evaluation module. The modeling modules are:

- A land use/economic module that covers the demand for space of various types. The module calculates floor space prices, and then the spatial location of households and jobs is determined based on maximizing utility and minimizing price. This module also covers the trip generation step of a travel demand model. The land market is responsive to zoning restrictions, development price, and travel impedances.
- An interface module that covers trip distribution for the trips generated in the land use module, based on information from the transportation module.
- A transportation module that that covers the mode split and traffic assignment portions of a travel demand model, with capacity constraint.

The travel impedances output by the transportation module are then used as inputs for the land use module for the next time period. Typically the model would be run for several five-year time increments under several scenarios, and the outputs from the final year compared using the evaluation module.

MEPLAN has an interesting feature that can change the total future population and employment in a region if policies make the region more attractive to potential migrants. This captures a dynamic seldom covered in land use models, however, it makes the results difficult to interpret. Some people may have difficulty accepting the idea that the effects of good policies may be partially offset by attracting a higher population to their region.

Fatal Flaws: This package has a travel demand model (TDM) embedded in it that is less powerful than SCAG's stand-alone TDM. Instead of integrating with SCAG's travel demand model, it would offer a less powerful replacement.

TRANUS: This package converts economic flows (household-to-industry, industry-to-industry, internal-to-external, etc.) into flows of people and cargo. These flows are then fed into mode split and assignment modules similar to those in a conventional travel demand model. Outputs include those normally produced by a conventional model (V/C ratios, congested speeds, etc.) as well as global indicators (overall mode split, average travel times, etc.) and cost and revenue indicators for transit operators. Allocation of new growth is

performed using logit models with travel times between zones taken from the previous model period. Zoning and development prices also affect new growth.

> *Fatal Flaws:* This package has a travel demand model embedded in it that is less powerful than SCAG's stand-alone TDM. Instead of integrating with SCAG's travel demand model, it would offer a less powerful replacement.

UPLAN: This is a rules-based package run in ArcView GIS. The user calculates how much new land of each type is needed based on population growth and the average density for each land use category. The relative attractiveness of developable sites is determined based on several characteristics, but chiefly accessibility. New development is then allocated based on General Plan allowable uses, access to transportation facilities (attractors) and restrictions due to topography and/or environmental constraints.

> *Fatal Flaws:* Does not include pricing, income, or market mechanisms as either inputs or outputs. Outcomes depend heavily on the user's ability to forecast demand for each land use type. For example, the model does not cover the real-life trade-off between a small well-located lot and a larger lot in a less convenient location, but relies on the user to determine the correct demand for each lot size. Caltrans' evaluation concluded that it could be suitable for COGs that lack the resources to develop more complex models.

DRAM/EMPAL: This package was developed thirty years ago. It has been the most widely-used land use forecasting package in the U.S. and so can be considered the industry standard (one review found that it was being used or had been used by two-thirds of the MPOs that had land use models). It uses an economic base multiplier to determine the amount of new growth, which is then distributed using a gravity model. The number of new households allocated to a zone is a function of travel impedance to worksites and the site's attractiveness (vacant developable land, percentage of land already developed, distribution of households by income quartile, and the area of residential land). Four to eight employment types are modeled. New employment is allocated based on travel impedance between zones and a lagged employment variable.

> *Fatal Flaws:* This model represents a limited number of behavioral factors, and does not include the role of zoning or development price. Therefore the impact of zoning changes, monetary incentives to develop in one place as opposed to another, and non-monetary incentives (such as reduced parking requirements) that affect development costs cannot be tested using this model.

Most of the MPOs using this package seem generally satisfied with it, and FHWA and USEPA implicitly approve its use. However, this could be because most installations occurred years ago when better options were not available. SCAG tried to develop a model using this package in the 1990s but abandoned the effort due to questions about the reasonableness of the forecasts and political acceptability. Any model that SCAG has already tried and rejected should be considered fatally flawed politically.

METROPILUS: METROPILUS was developed in the 1990s as an integrated version of DRAM/EMPAL that combined employment location, residence location/housing prices and land consumption in a single package. METROPILUS is embedded in a GIS environment (ArcView). Like the parent DRAM/EMPAL models, there is limited responsiveness to key land use planning policy variables. It has been implemented by the North Central Texas Council of Governments (NCTCOG) and San Antonio – Bexar County MPO.

> *Fatal Flaws:* Though GIS-based and integrated with respect to the employment and residential models, METROPILUS still exhibits the same fatal flaws as other DRAM/EMPAL applications.

What If?: This package is a combined GIS/spreadsheet application designed for use in community visioning workshops. The user inputs land use characteristics, a weighting for each characteristic, estimated population and employment growth, and infrastructure availability. The program consists of three modules, a Suitability Module that determines what purposes each piece of land is suited to, a Growth Module that forecast future demand by land use category, and an Allocation Module that allocates the forecast future demand among the available areas based on their suitability. The suitability module allows the user to introduce policies regarding conversion of land from one use to another, e.g., restrictions on the conversion of agricultural land to housing.

> *Fatal Flaws:* Does not include pricing, income, or market mechanisms as either inputs or outputs. Travel impedances to destinations across the region (i.e. the link to the travel demand model) do not factor into the model (either a site has road access or not; travel time to destinations is not a factor in the model).

INDEX: This package is a combined GIS/spreadsheet application that evaluates a given land use scenario based on indicators selected by the user, such as walkability or vehicle-trips per capita. It is best used in static conditions, e.g., comparing several proposed land use configurations for the same study year. The package has some capacity to predict changes in land use over time; however, it does this using a simple gravity model.

Fatal Flaws: Does not include pricing, income, or market mechanisms as either inputs or outputs. Travel impedances to destinations across the region (i.e., the link to the travel demand model) do not factor into the model.

CUF-2: This is a rules-based modeling package developed at UC Berkeley. The model focuses on developers' decisions on whether and how to develop land based on optimizing profit. Residential development is forecast using bottom-up growth forecasts for each jurisdiction. Employment is projected at the ZIP code level. Single-family, multi-family and non-residential uses (retail, office, and industrial uses) are allocated to developable land units (defined as one-hectare grid cells) based on the profitability of each use; the calculation of profitability includes consideration of user-specified development restrictions and/or incentives. The model is sensitive to policies that change either the cost of inputs or the selling price of developed land.

Forecasts are performed using a series of econometric models that project future population, households, and employment by jurisdiction at ten-year intervals. The equations used to project population and households are that same as those used in the *CUF-1* model. *County Business Pattern* data for 1981, 1989, and 1993 were used to prepare employment projections for thirteen three-digit SIC sectors. Employment estimates were prepared for ZIP code areas and aggregated by city and sector. Separate projection models were developed for each employment sector" (Lee et al 1999, pp. 37-38). The model is based on two datasets (1985 and 1995) and reportedly the calibration exhibited some low R-squares. This package is not available off-the-shelf.

Fatal Flaws: The package is not available off-the-shelf, it is data intensive, and interpreting the models requires detailed knowledge of statistics. Land uses are limited to four types of development and three types of redevelopment.

HLFM II+: This package is similar to DRAM/EMPAL but somewhat simpler. It was designed for use by smaller MPOs with limited budget and staff, but has been used by the Baltimore Regional Council. It considers accessibility and land availability as the key factors influencing location choice. The model starts with the location of "basic industry," then computes conditional probabilities for worker residential location and for service sector employees.

Fatal Flaws: Vacant land is the only measure of attractiveness, little behavioral content, no disaggregation of households by income or life cycle, not easily used for analysis of policies.

PLACE^{3}S: This is a GIS package that enables the user to input land use scenarios and then generates a variety of indicators of land, water, and energy consumption. The land use scenario can be aggregated to TAZs for input into a travel demand model. SCAG is currently using a version of Places3 for the Compass workshops.

> *Fatal Flaws:* This package is intended for testing of land use scenarios input by the user. It is not a predictive model.

SmartPlaces: This is an ESRI ArcView application that enables the user to input land use scenarios and then generates a variety of indicators of land, water, and energy consumption.

> *Fatal Flaws:* Not a predictive model; future land development is an input entered by the user.

LUTRIM: This package computes accessibility to jobs and households using a gravity model and then forecasts the location of new households and jobs based on accessibility, with basic industry and service jobs done separately. It integrates easily with TDMs, essentially operating as a "fifth step" using TDM friction factors and skim matrices as inputs. The model is unusual in that it is calibrated to a previously-produced land use forecast rather than to field data. This means the model is not capable of generating a new land use forecast, only for refining previous, exogenous forecasts.

> *Fatal Flaws:* The fact that the model is calibrated to reproduce a previous forecast, rather than field behavior, would make its forecasts of future land uses highly questionable. It does not appear to offer much scope for supporting policy analysis as it is lacking an economic theory base, and contains no demographic models (Zhao and Chung 2006, p. 10). It is not GIS-based, so integration with TransCAD could be problematic.

TOPAZ: Technique for Optimum Placement of Activities into Zones is an Australian linear programming model that determines the optimum placement of new households and employment so as to minimize transportation and development costs.

> *Fatal Flaws:* Does not model actual locational decision-making behavior, but rather determines what these decisions should be if all location decisions were centralized and optimized to reduce the total cost to society.

POLIS: Projective Optimization Land use Information System is a linear programming model that determines the optimum placement of new households and employment so as to maximize locational benefits. POLIS

allows the user to set constraints based on housing and land supplies and the development policies of different jurisdictions. ABAG used POLIS to model the Bay Area in the 1980s.

Fatal Flaws: Does not model actual locational decision-making behavior, but rather determines what these decisions should be if all location decisions were centralized and optimized to reduce the total cost to society.

SHORT LIST

From the information above, we developed an initial short list, which contained the following models:

- PECAS
- URBANSIM
- METROSIM

We forwarded this recommendation to the Delphi Panel, which is discussed in further detail in subsequent sections of the report.

4. DELPHI PANEL

To assist in the review and evaluation of the various Integrated Land Use/Transportation Models, we convened a Delphi Panel composed of various persons with interest and knowledge of these types of models. This chapter includes the following information:

1. What is a Delphi Panel and how is it used?
2. Who was considered for the panel?
3. What persons were finally selected to be on the panel?
4. What materials were sent to the panelists?
5. What responses have been received to date?

WHAT IS A DELPHI PANEL?

A Delphi Panel is used to support a decision making process through an application of the Delphi Method. The Delphi Method uses a panel of carefully selected experts who answer a series of questionnaires. Questions are usually formulated hypothetically, and experts state and support their answers based on their expertise as well as on background data provided to them with the questionnaires.

The key elements of the Delphi Method include:

- Structuring of Information Flow – Delphi participants are provided with a set of questions that they have to consider and information to be used in answering those questions. Instead of open-ended questions, it is more common to ask respondents to choose between several options.
- Regular Feedback – Ideally, there are several rounds involved in which participants prepare responses, review others' responses, and then finalize theirs. The convergence occurs through this feedback process.
- Anonymity of the Participants – Participants are also anonymous with respect to each other. Therefore, the parties participating in the process do not know who has authored what response (except for their own). It is thought that this anonymity encourages freer discussion among the participants.

WHO WAS CONSIDERED FOR THE PANEL?

In selecting panel participants, we looked for potential members who fell into one or more of the following categories:

- Current Users – Persons in this category include those with direct hands-on experience working with an Integrated Land Use/Transportation Model. Preference is given for those who are using either URBANSIM or PECAS since those packages were most heavily considered. Persons in this category could include private consultants, agency or university staff. The rationale for selecting these persons is that they should have the most experience working with a model and should provide significant insight regarding day to day use.

- Agency Staff Evaluating Integrated Land Use/Transportation Models – Persons in this category would include persons at various government agencies, either MPOs or State Departments of Transportation, who are currently evaluating various Integrated Land Use/Transportation Models for use by their agency. The rationale for selecting these persons that their participation in a process similar to the one undertaken by SCAG may allow them to share their experience.

- Agency Staff Implementing Integrated Land Use/Transportation Models – Persons in this category are involved in implementation of an integrated model but lack hands-on experience. The implementation process is defined as either the model development or the use of an existing model. An example might be an MPO staff person who is overseeing the development of an integrated model but is not working with the model on a day to day basis. The rationale for selecting these persons is that they should have an understanding of entire implementation process including data collection, model development, and reviewing the model output.

- Academics with an Interest in Land Use/Transportation Issues – These persons would include university professors who have an interest in land use and transportation. The rationale for selecting these persons is that they should have an understanding of the theory behind an integrated land use model and other larger macro-level issues.

In considering potential members, we also applied the following general criteria:

- Participants should be selected from a variety of backgrounds and locations. If we selected participants all from the same agency, there might be little variety in their responses.

- A majority of the respondents should be either hand-on users or those involved with the model implementation process.

- Care should be taken to select members such that at least one representative has hands-on experience with URBANSIM while another has experience with PECAS, given that those two packages were rated most highly in our initial study and other studies.

PERSONS SELECTED FOR THE PANEL

The following persons were selected for the Delphi Panel:

- Keith Lawton – Mr. Lawton is a consultant and former Director of Portland Metro. He has led the development of a comprehensive set of transportation models for use by all jurisdictions in the Portland area. He has also led the development of interactive transportation and land use models. He has been a member of numerous model review and expert panels at MPOs around the country.

- Gordon Garry – Mr. Garry is Sacramento Area Council of Governments' Director of Research and Analysis. Mr. Garry was responsible for development and application of modeling for the Sacramento region's innovative and influential Blueprint Project. He is currently directing the implantation of a PECAS model for the Sacramento region.

- Eric Miller – Mr. Miller is University of Toronto Professor and Chair, Civil Engineering Department. Prof. Miller's research interests include the micro-simulation of urban transportation and land-use systems, the sustainability of urban transportation systems, and improvements in conventional travel demand models.

- John Landis – Mr. Landis is professor and past Chair, Department of City and Regional Planning at the University of California, Berkeley. Prof. Landis is a long-time leader in the field of land use forecasting and was the primary developer of the influential BASS and California Urban Futures models.

- Ned Hacker – Mr. Hacker is a senior planner with the Wasatch Front Regional Council (the MPO for the Salt Lake City region) and is overseeing the development of a regional URBANSIM model for the Salt Lake City region.

MATERIALS SENT TO EACH PANEL PARTICIPANT

The following materials were sent to each participant:

- An invitation letter
- A copy of our Needs Assessment (Chapter 2)
- A copy of our Model Long List (see Chapter 3)

RESPONSES

We received three responses from the following parties:

- Keith Lawton
- Eric Miller
- WFRC staff (responding for Ned Hacker)

<u>Question 1:</u> Do you agree with the consultants' assessment that PECAS and URBANSIM and METROSIM are the best candidate packages for use in the SCAG region given SCAG's Statutory Requirements and other features desired by SCAG?

Respondent #1

Yes I agree with the selected short list of PECAS, URBANSIM and METROSIM. I also agree with the general discussion of the "long list" of models and the relative evaluation of them. In particular:

- MEPLAN and TRANUS are dominated by PECAS, which I view as a "next generation" model in the MEPLAN/TRANUS model "family". I think PECAS is a significantly improved version of the spatial I-O approach to land use modeling.

- DRAM/EMPAL and/or METROPILUS are very old technology and do not adequately address the range of SCAG's needs. In particular, the poor treatment of housing markets in these models is, in my view, a fatal flaw in and of itself.
- All the various GIS/spreadsheet packages may be useful for some exploratory/descriptive type analyses but they are not, in my view, appropriate forecasting tools.
- The optimizing models (TOPAZ, POLIS) are not suitable for the forecasting applications required here, as noted in Appendix B.

DELTA is a model that I might have considered for the short list, but it is likely that it does not bring much to the table that is new and different relative to the three included in the short list. Plus the lack of US application and the scale of the SCAG application are probably of some concern, although I would not weight these issues too heavily. On balance, I am comfortable not including it.

One model not included in the long list in Appendix B is MUSSA, the model developed for Santiago by Prof. Francisco Martinez from the University of Chile. Although not a commercial package, this model has been in very successful application in Santiago for some time. It has a very strong microeconomic foundation (bid choice theory). In terms of model quality and performance I would say that it is the equal of the three chosen. The transferability to the US context and to the scale of the SCAG region, as with DELTA, is something of a concern. More important, I think it would be difficult to transfer the model given its non-commercial foundation and the lack of experience with transferability of this model. On balance, I am comfortable not including MUSSA in the short list.

Respondent #2

Yes. I am more familiar with PECAS, and like the economic linking with commodity flows – and hence a way into freight. A question for me is the demonstrated real calibration and application of any of these models. The METROSIM model approach was applied at Metro (Portland) by Sonny Conder (in-house model – "MetroScope") – and appeared to be tractable and useful – but no freight component. The EJ is a micro-simulation of traveler - travel demand model issue – is covered if an activity-based travel model is used.

Respondent #3

Yes, we agree with the consultants' assessment. From the model implementation perspective, the availability of software source code is also very important. The source code allows the user to tailor the model structure to various needs. The source code makes the debugging easier.

<u>Question 2:</u> Based on your knowledge and on the criteria listed in Question 1, what would your recommendation be for the ILUTP package for use in the SCAG region?

_1__ PECAS
_2__ URBANSIM
_3__ METROSIM
___ Other Package: _____

Please support your recommendation, including consideration of the criteria listed in Question 1 as well as other factors you believe to be relevant (e.g., relative ease of implementation):

Respondent #1

In terms of many of the criteria listed above, I am not convinced that there is necessarily a lot to choose from among the three packages; i.e., all three, I am sure can be made to work well. E.g., with respect to transit analysis, revenue analysis, working at different scales, EJ, etc. I am not sure that any of the packages would particularly dominate any of the others. Air quality analysis, it seems to me, is largely a question of the interface between the transportation network model and the emissions model being used and will not be much affected by whatever land use model is used (as long as the land use model is getting its fundamental outputs of population and employment distributions and their linkages "right").

I must confess that I don't have a good sense of the GIS capabilities of PECAS and METROSIM, but I assume that they are at least acceptable, if not more so. URBANSIM's GIS capabilities are, I do know, quite good. But I would not choose a package based on this criterion, since appropriate GIS capabilities can always be achieved these days without excessive effort.

My ranking of the three packages is primarily based on their theoretical structure, from which I see important relative strengths and weaknesses flowing. In my view PECAS has the strongest and most

appealing theoretical structure. The spatial I-O approach, although somewhat data-hungry, is conceptually a very appealing representation of the urban spatial economy, from which spatial interactions (i.e., travel and goods movements) flow. Important practical advantages that follow from this theoretical structure include the following:

- It handles land market supply-demand-price interactions in a consistent, coherent, comprehensive and credible manner. I am not a fan of URBANSIM's treatment of price formation and hence demand-supply interactions. I find it overly ad hoc and difficult to justify. In particular, the implementation details of the price model I find quite crude relative to the conceptual, overview descriptions usually provided for the model. METROSIM, on the other hand, I find over-emphasizes a strict equilibrium resolution of demand-supply that I don't think properly captures land market dynamics.

- It provides a comprehensive framework for consistently handling all spatial processes of interest within the model system. Again, in my view URBANSIM tends to be ad hoc in how it handles different processes, while METROSIM is primarily a housing and labor market model and does not necessarily generalize well to other processes.

- In particular, PECAS is the only model system of the three that intrinsically deals with goods movements in an integrated fashion. With the other two models, goods movements would have to be handled as a completely separate phenomenon.

Respondent #2

This model (PECAS) has been calibrated for Sacramento and for Oregon (Statewide), in both cases with an activity based travel model. I believe that it is also the base for the Ohio statewide model. In the Oregon case the structure has been set up for scaling to an adequate level of detail. Freight is covered explicitly and is endogenous to the model's structure. The ability to handle AQ is primarily derived from the structure of the transport model. The explicit production element in the model should also allow modeling of non-transport emissions.

With explicit market-clearing, housing prices etc. should be available. It is not clear to me whether a non-equilibrium approach (which I understand is the URBANSIM approach) can adequately handle this issue.

Most of the EJ issues can be addressed (Transportation) with a transportation model that models each member of the population sequentially – and is dependent on the model form. Currently this procedure is implemented in all of the activity and tour-based models that have been implemented, it is not clear whether this can be done for trip-based – but certainly cannot be done with matrix based aggregate application models (which all current trip-based, so-called 4-step models are).

In short, I believe PECAS meets all the criteria listed.

Ease of implementation: None of these models is easy to implement – they all take significant effort. In theory, the METROSIM model might be the easiest to implement, but I am not familiar with any implementations, other than the METROSIM – like model built at Metro in Portland, OR.

Respondent #3

We are the URBANSIM user now. Part of the reasons that we selected URBANSIM:

- URBANSIM is an Agent-based model to reflect the discrete choice behavior
- URBANSIM involves a land price model
- URBANSIM has a good transportation/land use interaction
- URBANSIM can deal with redevelopment and infill potential
- URBANSIM is source code free software; now OPUS is coded with Python which is easy for users
- The University of Washington is very, very supportive

SUMMARY

In reviewing the Delphi Panel Responses, we can conclude the following:

- The Panel generally agrees with the initial results in that we narrowed the field down to URBANSIM, PECAS, and METROSIM.
- The panel appears to be split between PECAS and URBANSIM.

- The proponents of PECAS provide more extensive support for their choice. Key elements in support of PECAS include a better theoretical approach to land prices and superior treatment of goods movement.
- The proponent of URBANSIM provides some evidence to support their choice but not as extensive as others. Some positive aspects of URBANSIM include good technical support and the availability of the source code.

5. EVALUATION CRITERIA

As part of our evaluation process, we considered information we had gathered regarding the two main integrated models we were evaluating from the following sources:

- Current users of each model
- Participants in our Delphi Panel process
- Previous studies discussing various integrated models. One example study was prepared by the University of California Davis entitled *Assessment of Integrated Transportation/Land Use Models* (May 2006).
- Materials published by the developers of each integrated model
- Information regarding SCAG's needs and interests based on extensive interviews with staff

A key element of our evaluation process was the development of evaluation criteria. We compared the performance of each model against the criteria to determine how each model performed in that respect. The main input into the evaluation criteria was the surveys we conducted for SCAG staff. These surveys were documented in a technical memorandum we prepared on January 30, 2007 discussing SCAG's needs.

The criteria are shown in Table 1 below.

Table 1
Recommended Evaluation Criteria

Category	Criteria	Reason
Travel Demand Model	Compatibility With TransCAD Model	SCAG working on TransCAD model at this time, will be modeling platform used by SCAG for next 5-10 years. ILU Model should interface with TransCAD level on general inputs and outputs.
	Compatibility with Activity Based Models	SCAG considering move to activity-based models. ILU Model should have the potential to interface with an activity-based model at some level of general inputs and outputs.
SCAG Duties	Ability to Forecast Housing Affordability	Identified in Needs Assessment as a major concern of SCAG staff. We expect housing affordability to be a major concern in the region for the next 15-20 years. ILU Model needs to be sensitive to the amount and location of affordable housing.
	Ability to analyze or provide outputs for Air Quality Analysis	Identified in Needs Assessment as a major concern of SCAG staff. We expect this issue to be a major concern in the region for the next 15-20 years. ILU Model should either output this information directly or interface with other models (travel demand model or air quality model) that performs the necessary calculations.
	Ability to Analyze TOD Projects	Major policy endeavor for SCAG is Compass 2% project. Model should have some ability to analyze/forecast either individual TOD's or more general TOD strategies. We expect that TOD-type developments will be a major focus in region as transit facilities are expanded. Similar projects would include infill and redevelopment projects. ILU Model should analyze these types of projects either through sensitivity to factors that concentrate development in TOD areas or by direct manipulation of the land use inputs. We anticipate that a major use of the model will be in alternative or scenario testing related to various Smart Growth proposals.
	Ability to Forecast/Analyze Goods Movement	Goods Movement is a priority for SCAG as evidenced by previous and ongoing studies. We expect this focus to remain in the future. Freight is a significant issue in the region with various ports, airports, rail, and truck facilities. One important aspect to freight is secondary distribution (what happens after freight arrives at a warehouse or distribution center). ILU should have a strong freight component and allow the analysis of various

Table 1
Recommended Evaluation Criteria

Category	Criteria	Reason
		issues related to the freight.
	Ability to reflect market and exogenous forces	ILU should be sensitive to market forces like rents, home sales trends, water and school capacity, as well as exogenous events, such as major shifts in the economy, fuel prices, new regulatory requirements, availability of investment capital, and other factors.
	Ability to provide demographic forecasts	A key task for SCAG is developing demographic forecasts which are inputs to a variety of planning studies such as the Travel Demand Model, the Regional Transportation Plan, and other related items. The model should be able to either provide the demographic forecasts directly or provide input on the forecasting process.
	Model sensitivity to policies and planning assumptions at the regional level	The ILU should be sensitive to major regional policy directions and regional assumptions. For example, SCAG may set regional population caps for counties or other areas within the model based on the application of other methods.
Model Structure	Level of GIS Integration	Integration with GIS is a key element. This integration would include the use of GIS system to develop input data and GIS to output the data as well.
	Ability to Work at Different Scales	This criterion reflects two concerns. First, the model may have zones of varying sizes which could range from the City level to the travel model TAZ level or smaller. Second, the model may be applied to various planning studies which could be regional or at the local city level. Implementation of the model is likely to occur in a phased approach whereby the model is initially built at a more aggregate geographic scale and then further refinement is made.
Implementation and Maintenance	Vendor Support	SCAG will need significant support from the vendor in implementing the model. We will consider the experience of other agencies when evaluating the ability of each vendor to support their project. If the vendor is unable to support the software at a high level, additional consultant support would be

Table 1
Recommended Evaluation Criteria

Category	Criteria	Reason
		needed.
	Ease of Modification	The model should be relatively easy to modify. The ease of modification depends on whether the model source code is available or whether there are other methods used to modify the model elements.
	Budget Requirement and Staff Resources	This criterion assesses the cost of implementing an Integrated Model and whether one model requires substantially less resources (staff and overall budget) than the other.
	Use by Other California Jurisdictions	Much of the LU model support is done at the peer-group level. Use of a model that will be used by other MPOs and agencies in California will allow SCAG staff to tap into their experience in apply and developing the model.
	Data Requirements	Data requirements between models could vary in terms of data availability, scale, flexibility, processing, and cost. A model would be rate higher if the data could be more easily obtained, if less data collection was required because the model used data already collected by SCAG, or if there was a significant difference in the level of data required.

Source: Fehr & Peers, 2007

6. PECAS EVALUATION

PECAS BACKGROUND

PECAS (Production, Exchange, and Consumption Allocation System) was developed by Douglas Hunt and others from the University of Calgary. The model has two main components including:

- Activity Allocation Module – This module determines the locations of different activities, determines what goods and services are produced at each location, and then estimates interactions between various land uses as they exchange goods and services. This module is implemented through a series of nested logit models.

- Space Development Module – This module determines changes in the land development pattern based on changes in the activity allocation module and input from a regional travel demand model. In this portion of the model, land is assumed to either remain in its existing use, become derelict, or transform into a different use. This module is also implemented through a series of logit models.

Some of the key components of PECAS include:

- Uses travel demand model information as an input and can also output data to the model

- Tracks flows of goods and services, which serve as the fundamental basis for the model operations. The analysis of goods movement is considered to be a significant strength of PECAS.

- Very data-intensive requiring land use data, land price data, regulatory information, and other related items. For model development purposes, data is required both for a base year and prior years. Land use data in multiple land use categories is required.

- Model source code is available for modification by a user

- Model interfaces with GIS in both the input and output process

- Model runs on yearly intervals to forecasts future growth

Current users of PECAS include the Sacramento Council of Governments (SACOG), the California Department of Transportation, the Baltimore Metropolitan Council, and the Ohio Department of Transportation. Figure 1 provides an overview of the model process used by PECAS.

PECAS PERFORMANCE

Our evaluation of PECAS is provided in Table A-1. As shown in this table, we evaluated the model against each of our criteria. For any criteria where the model performed in a less than optimal fashion, we also include discussions of how this deficiency could be remedied. For example, we determined that the vendor support for PECAS has been limited (Implementation and Maintenance). As a mitigating measure, we determined that additional staff resources and consultant support would be needed.

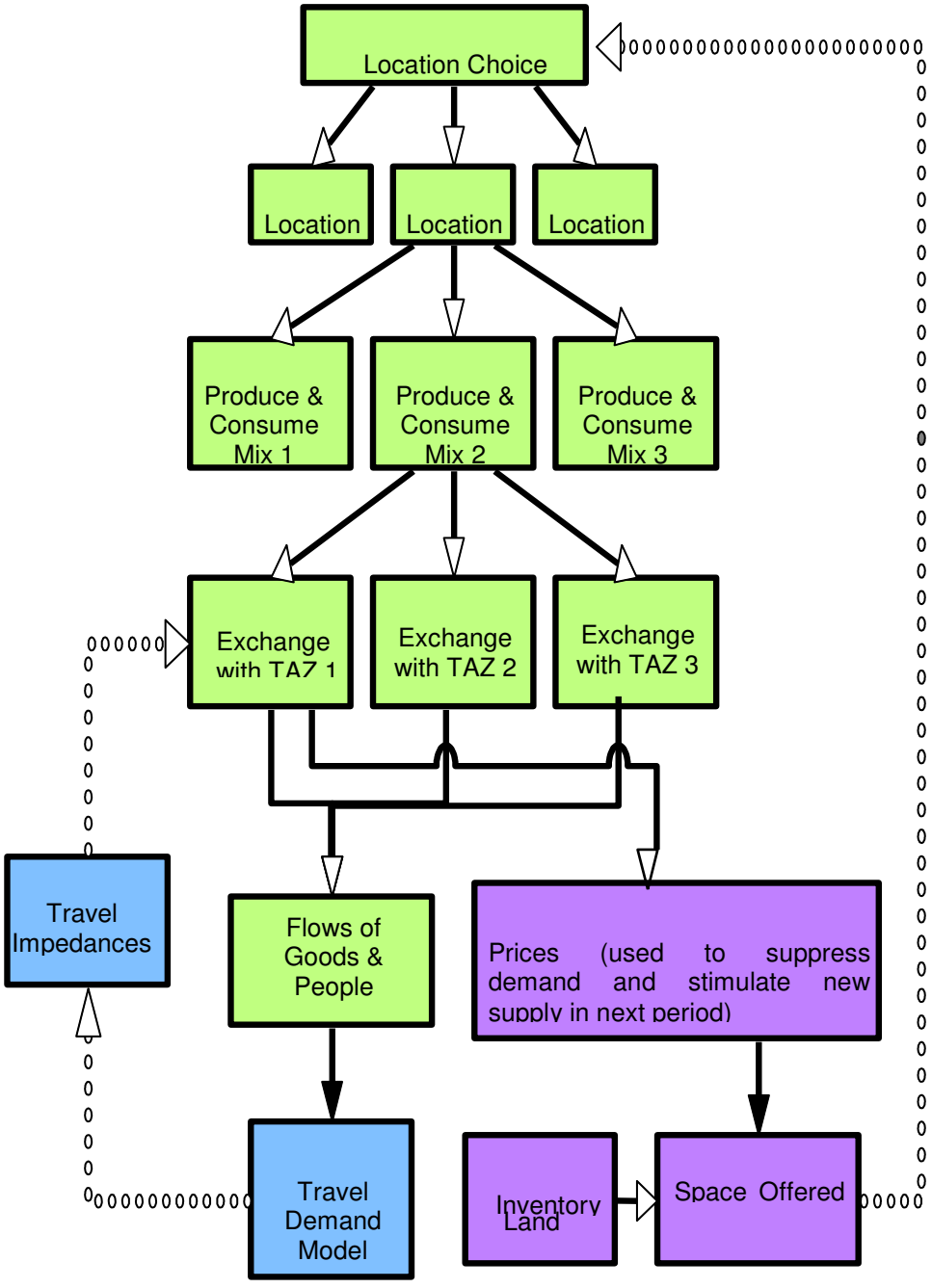
Areas where PECAS performed very well included:

- Compatibility with activity based models
- Ability to forecast/analyze goods movement
- Ability to provide demographic forecasts
- Ability to work at different scales
- Use by other California jurisdictions

Areas where PECAS performed not well included:

- Ability to analyze TOD projects
- Model sensitivity to policies and planning assumptions at the regional level
- Vendor support

Figure 1- PECAS Model Structure



7. URBANSIM EVALUATION

URBANSIM BACKGROUND

The second model we evaluated in detail was URBANSIM. URBANSIM was developed by Paul Waddell and others at the University of Washington. The URBANSIM model is composed of five modules including:

- Demographic and Economic Transition Module – This element of the model tracks the changes in population and employment through external changes not related to land use (births, deaths, job creation/loss, etc.).

- Household and Employment Mobility Module – This component of the model estimates the willingness of households and employees to move, based on historical data.

- Household and Employment Location Module – This element of the model replicates the location process by which mobile households and employees (those determined to be willing to relocate) are positioned.

- Real Estate Development Module – This portion of the model replicates the behavior of real estate developers by determining where new development/redevelopment may occur and the form in which it occurs.

- Land Price Module – This model component determines changes in land prices, using historical data and projected development activity.

Some key components of URBANSIM include:

- It is an agent based model in which the main actors are households, employees, and developers

- Integrates with a travel demand model at the input and output level

- Very data intensive with existing and historical data needed. The historical data is required to calibrate the model.

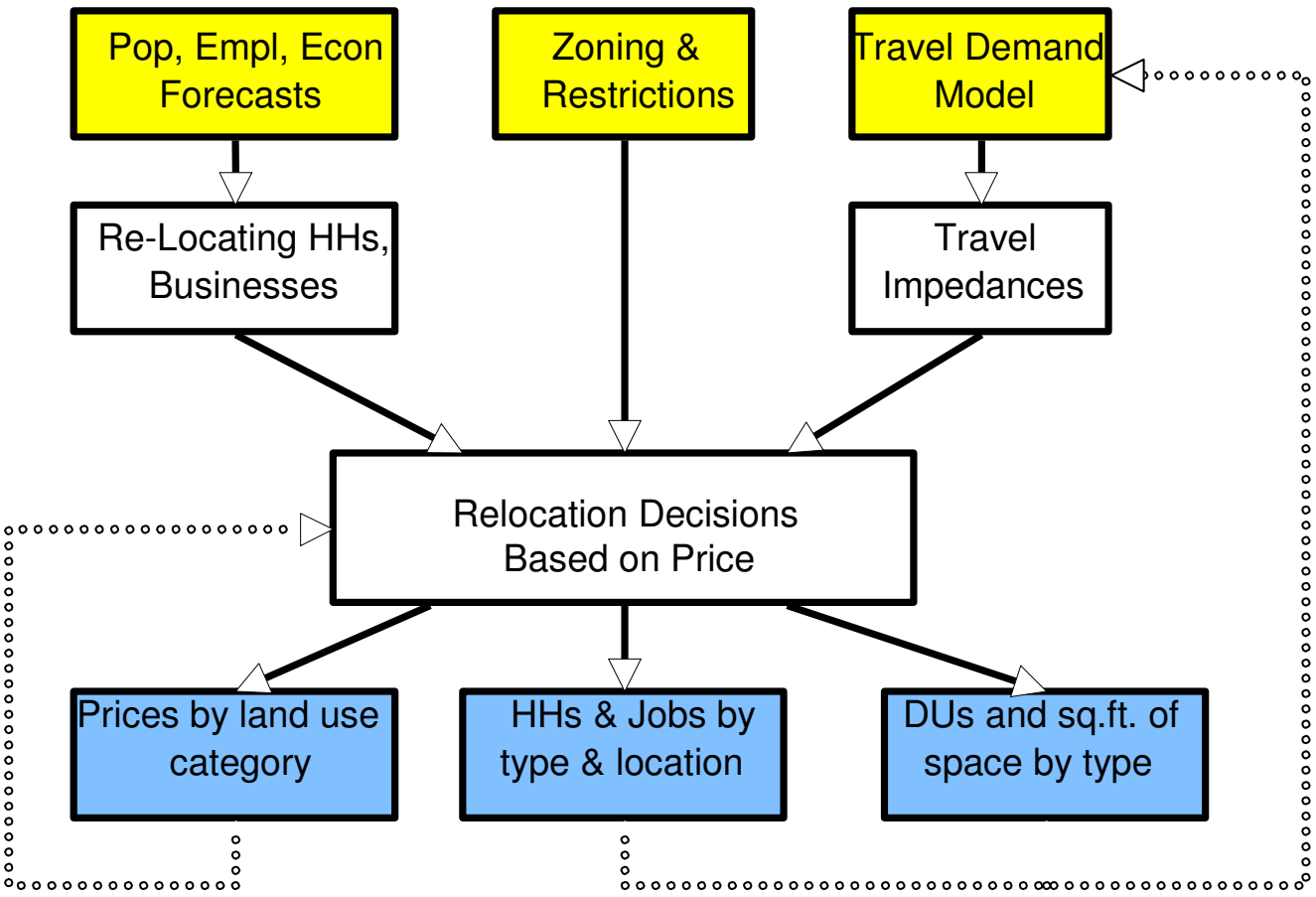
- Model source code is available for modification by a user

- Model interfaces with GIS in both the input and output processes. URBANSIM users note the ease of outputting data from the model to GIS software.

- The model also runs at yearly intervals to forecast growth

Current users of URBANSIM include the MPOs for Salt Lake City, Houston, Seattle, Detroit, and Honolulu. Figure 2 provides an overview of the process used by URBANSIM. An evaluation of the URBANSIM model is provided in Table A-2.

Figure 2- URBANSIM Model Structure



8. COMPARISON OF URBANSIM AND PECAS

Table A-3 details a comparison of PECAS against URBANSIM for all evaluation criteria. As shown in the table, the advantages of PECAS include:

- Compatibility with activity based models
- Ability to forecast/analyze goods movement
- Use by other California jurisdictions

In contract, the advantages of URBANSIM include:

- Model sensitivity to policies and planning assumptions at the regional level
- Vendor support
- Ease of modification

9. IMPLEMENTATION PLAN

ASSUMPTIONS

We have developed this implementation plan under the following assumptions:

- This effort will be followed by a more detailed model design study, which will provide additional information regarding data to be incorporated into the model, data sources, model structure, and even the modeling platform to be used.

- We are not recommending the use of particular model software (either PECAS or URBANSIM) at this time.

- Our implementation plan is modeled on the experience of SACOG and the Baltimore MPO, who are two agencies which have recently implemented integrated land use/transportation models.

- Our implementation plan recommends a phased approach for the model. This implementation covers the development of the initial model, which would reflect a zone system of approximately 200-300 zones. This zone system could be based on a subset of the Regional Statistical Areas (RSAs) or similar geography units currently used by SCAG. Not all of the data sources would have to be developed at the same geographic scale. We would note that several of the MPO's currently developing Integrated Models have applied different methodologies to develop these zone systems. For example, the SACOG model is based on somewhat arbitrary grouping of adjacent TAZ's from the Travel Model. Other MPO's have developed zones based on existing Census Geography or other aggregated geographic units.

TIMELINE

We anticipate that the model development process would likely take an additional four to five years at a minimum, which would include the following major steps:

- Stage 1: Model Design Study – In the model design study, the implementation process is further refined. A key component of the model design study would be identifying those variables for which data would be collected, which would guide the data collection and processing tasks. The model design study would also provide input on the staffing for the model and provide a more detailed schedule regarding the implementation. This model design study could also be tasked with recommending a particular modeling platform or this decision could be deferred until later stages. The model design study for the SACOG model was budgeted for approximately $200,000.

- Stage 2: Data Collection – Data would be collected for a wide variety of topic areas. Regardless of the modeling platform selected, much of the data required will relate to land use specifically parcel-level data. Additional information will be required related to land value data, including historical information needed for the model calibration process. We anticipate that much of the land value data would be available from commercial sources and would have to be purchased by SCAG or consultants working for SCAG.

- Stage 3: Data Processing – After data collection, data processing will be required. A key component of the data collection process would involve the aggregation or disaggregation of data to the level of the model zones. For example, it is recommended that model be constructed at an aggregate level (200-300 zones initially) as opposed to a fully disaggregated model based on the travel demand model structure (4000+ zones). The parcel data could be aggregated up to the zonal level while the land price information, which may only be available at the citywide or ZIP code level, could require disaggregation. It is thought that the use of GIS databases could simplify this process.

- Stage 4: Existing Year Model Development – This task would involve modifying the model structure to match the needs of SCAG. Examples of this coding could include modifying the structure of a PECAS model to incorporate zoning data. Regardless of whether PECAS or URBANSIM is implemented, some modification of the base model software would be required.

- Stage 5: Existing Model Calibration – The model calibration process involves a modification of the model parameters to reflect historical conditions. Key components of the model calibration would be ensuring that the model has the appropriate level of sensitivity to

turnover in land uses and also that the model predicts future development in appropriate locations.

- Stage 6: Future Model Development – Both PECAS and URBANSIM require that the future model be run in yearly intervals to arrive at a future scenario. Therefore, if a 2035 forecast is required, the model would be run at yearly intervals to arrive at this 2035 forecast from the Existing Year model. We do not anticipate that extensive recoding of the model would be required, as in the case of the Existing Year model.

An approximate breakdown of these various stages is shown below:

TABLE 2
APPROXIMATE TIME FRAME FOR SCAG INTEGRATED LAND USE MODEL DEVELOPMENT

Task	Year 1	Year 2	Year 3	Year 4	Year 5
Design Study					
Data Collection					
Data Processing					
Existing Model Development					
Model Calibration					
Future Model Development					

Source: Fehr & Peers, 2007

STAFFING

To develop the recommended staffing plan, we first considered what is the staff needed to operate and maintain the model on a regular basis, if the model is to be applied effectively. We have identified that there are several different skills required, which would include:

- Land Use Planning – Some of the staff involved in the model operation should have knowledge of land use planning issues that would enable them to critically view the model outputs. Land use planning knowledge would ensure that counter-intuitive model results are flagged before being distributed to other staff within SCAG. For example, the model may initially show increased growth within existing urban areas. A person with modeling or programming skills may not know enough about land use planning to determine if this result is reasonable or not. This ability to screen the results of the model will reduce the possibility for unreasonable results to be released, which could cause the model to be questioned.

We anticipate that a land use planner could also provide some benefit during the data collection and data processing stage. This experience would be helpful when the parcel level data is acquired and processed. The input of zoning data into the model could also benefit from the

oversight of a land use planner, particularly given the variety of zoning classification and systems used by the various Southern California cities and counties in the SCAG region.

- GIS Analysis – Another key staff member would be a person with GIS experience. A GIS operator would be needed to process the various data sources and their input into the model. Additionally, a GIS operator would be needed to process the various outputs produced either by PECAS or URBANSIM.
- Travel Demand Modeling – An integrated land use/transportation model will require inputs from the regional travel demand model. To facilitate the transfer of data between the regional travel demand model and the integrated model, a staff person with travel model experience will able to more easily facilitate this transfer.
- Computer Programming – A final key staff person would be a computer programmer. This programmer would be needed during the existing year model development and the model calibration process. Ongoing computer programming support could also be needed during the future year model development. A computer programmer would also be needed if the model is subjective to additional refinement, as might occur if the model is geographically disaggregated beyond the initial setup.

When identifying staff persons to staff the model development, calibration, and operation, we would recommend that SCAG consider the following items:

- Staff Continuity – It is absolutely critical that staff members involved the initial stages of the model development continue to work on the model as it is applied. Be continuing to work on the model, the "institutional memory" will be maintained. If staff persons are rotated in and out to work on the model on a continuous basis, it will be difficult to maintain this continuity.
- Involvement of Multiple Staff Persons – Another key consideration is that multiple staff persons should be involved in the model development and operation. By maintaining the involvement of multiple staff persons, it lessens the possibility that the loss of a single person as a staff person leaves SCAG would significantly impair the model process.

In reviewing staffing plans at other MPOs, we noted that there are two differing approaches to the use of multiple staff. At least one MPO has a single staff person who is heavily involved in model development. In other MPOs, the model is staffed by multiple persons. For example, SACOG is proposing to have 4-5 staff persons involved in the day-to-day operation of the model.

- Skill Overlap – It is possible to staff the model with staff persons who possess multiple skills. For example, a staff person with both GIS and land use planning experience might be found, as these skills are sometimes found in planners. Travel demand modelers also sometimes have experience using GIS.

- Level of Expertise – While it might be possible to staff the model development, calibration, and operation with several generalists; several of the staff persons will need high levels of expertise. This expertise will be especially necessary in the area of GIS analysis and computer programming. At least one person with a high level of skill in GIS analysis and computer programming would be needed to staff the model.

OUTSIDE CONSULTANTS

It is likely that outside consultants will be required to support this effort in several roles including:

- Model Design Study – A key task allocated to outside consultants would be the model design study.
- Data Collection and Processing – The collection and processing of data will likely require outside assistance from specialized consultants. For example, there are numerous land use planning firms that would be able to assist SCAG with the processing of parcel level and zoning data.
- Existing Model Development – Consultants could also be employed to perform much of the programming modifications under either a PECAS or URBANSIM model.
- Model Calibration – Alternately, consultants could be tasked with the model calibration.
- Future Model Development – Another role for consultants could be to develop the future year model, including obtaining data from future year travel demand model.

We anticipate that there will need to be extensive use of outside consultants with specialized expertise, although we would recommend that there is an appropriate balance between the use of SCAG staff and consultants. We would not recommend that the burden for the entire model development and calibration process be placed entirely on SCAG staff or outside consultants.

ORGANIZATION

Given the above information, we would recommend that SCAG adopt the following organization for the model development/calibration/operation process:

- There should be a designated group of staff persons working on the model who are involved in the process from the beginning.
- These staff persons should be maintained as a group, working together. We would not recommend shifting staff in and out of this group, except as necessary.
- This group should be composed of at least 4-5 persons (at a minimum) with at least 1 person with a land use planning background, 1 person with a traveling demand modeling background, 1 person with a high level of GIS analysis expertise, and 1 person proficient in computer programming.
- This group should also employ outside consultants as necessary. Likely tasks allocated to these consultants would be the model design study, data collection and processing, and support for SCAG staff in the model development, calibration, and model operation.
- Based on the above considerations, we would also recommend that one person be designated to oversee the entire process (model coordinator). This person would have an overall understanding of the model processes but may not be familiar with all technical details. This person would oversee both the SCAG staff and the outside consultants.
- Not all of these staff persons would be needed initially, with only a model coordinator required to oversee the model design study and data collection. As the process continued, additional staff could be brought in to work on the model.

BUDGET

In considering the potential budget for this effort, we applied the following assumptions:

- Most regions have spent an average of $250,000 a year on model development with several larger regions or states spending upwards of $500,000 to $750,000 a year. It is likely that the cost required for the SCAG region would be in the upper bound of these costs.

- Much of the costs would be related to the acquisition and processing of data (parcel data, land cost, etc.).

- The cost of hiring staff is not included, as existing SCAG staff could be tasked to work on the project.
- These cost estimates do reflect the cost of hiring outside consultants and purchasing the needed data. Even data obtained by SCAG from local governments, such as parcel and zoning data, will require extensive processing.
- Given the various uncertainties, we are identifying a range of costs for each year.

Our estimated budget for this effort is provided in Table 3 below.

TABLE 3

APPROXIMATE COSTS FOR SCAG INTEGRATED LAND USE MODEL DEVELOPMENT

Year	Lower Range	Upper Range	Tasks
1	$250,000	$500,000	Model Design Study, Data Collection
2	$750,000	$1,500,000	Data Collection, Data Processing Existing Model Development
3	$500,000	$1,000,000	Data Processing Existing Model Development
4	$500,000	$750,000	Model Calibration
5	$500,000	$750,000	Future Model Development
Totals	**$2,500,000**	**$4,500,000**	

Source: Fehr & Peers, 2007

10. INTEGRATION WITH THE TRAVEL DEMAND MODEL

INTRODUCTION

The SCAG Regional Travel Demand Model is a key analytical tool used in a variety of analytical studies. This model produces future transportation forecasts, based on socio-economic and transportation system inputs. The Regional Model was recently updated to operate under the TransCAD platform.

In considering how to integrate the two models (Regional Travel Demand Model and the Land Use/Transportation Model), we applied the following assumptions:

- Thentegrated Land Use/Transportation Model would not entirely replace the Regional Travel Demand Model and both models would continue to be used for a variety of studies.
- The Integrated Land Use/Transportation Model would require outputs from the travel demand model including travel times for use by either the PECAS or URBANSIM model.
- The potential avenues of integration might occur through the transfer of information from the Integrated Model to the Regional Model or the transfer of information from the Regional Travel Demand Model to the Integrated Land Use/Transportation Model
- We also evaluated the need to make systematic changes to the Regional Travel Demand Model to allow the Integrated Land Use/Transportation Model to be used. For this evaluation, we consulted with the developer of the TransCAD software (Caliper) and other MPO's that are developing Integrated models.

TRANSFER OF INFORMATION FROM THE INTEGRATED MODEL TO THE TRAVEL MODEL

The highest level of integration is likely to occur as the Integrated Model is used to provide socio-economic data inputs into the Travel Model, which would provide the following benefits:

- The land use data used by the Travel Model, which is a key input in the traffic forecasts. The land use forecasts from the Integrated Model which would represent the most accurate assessment of future land uses. The use of Integrated Model forecasts will also provide additional defensibility, if the land use forecasts in the Travel Model are questioned.
- Using the land use forecasts from the Integrated Model in the Travel Model will facilitate the analysis of transportation benefits attributable to various land use planning efforts.
- The Travel Model can provide additional analysis beyond that provided by the Integrated Model. For example, both Integrated Models we evaluated do not provide any analysis of air quality. Since the Travel Model provides outputs to the Air Quality model, air quality impacts of various land use scenarios can be evaluated indirectly.

TRANSFER OF INFORMATION FROM THE TRAVEL MODEL TO THE INTEGRATED MODEL

The Integrated Model will also require the use of some inputs from the Travel Model, including estimates of travel time between various locations. These estimates of travel time are a key factor used in the distribution process by which future development/redevelopment is allocated.

To facilitate use of these travel times, several adjustments may need to be made to the Travel Model including:

- The Integrated Model is likely to use a more refined or aggregated zone system than that employed in the Travel Model. Some method of correspondence between the two systems is required. A discussion of a potential zone system for the Integrated Model is provided in Chapter 9.

- Both of the Integrated Models evaluated (PECAS and URBANSIM) recommend developing future forecasts based yearly iterations of the travel model. For each year the Integrated Model is run, output from the Travel Model will be required. The documentation for URBANSIM suggests that if yearly iterations of the Travel Model are not available, then iterations at run at 5-year intervals would suffice. Currently, the Travel Model only includes an Existing Year and Forecast Year; therefore several interval years would be required.

SYSTEMATIC CHANGES TO THE TRAVEL MODEL

We consulted with several persons to determine if there would be a need to make systematic changes to the Travel Demand Model to facilitate transfer of data to/from the Travel Model. We were not able to identify any significant incompatibilities between TransCAD and the either PECAS or URBANSIM. The only major issue is likely to be the differences in zone systems between the Integrated Model and the Travel Model.

In our review of modeling efforts currently underway at SCAG, we noted that the current Sketch Plan Model Development provides some opportunity to more easily translate data between the various model types. The purpose of the Sketch Plan is to create a more aggregated version of the Travel Model for use in various planning efforts. Some advantages of using the Sketch Plan model in this capacity include:

- The Sketch Plan model is likely to have far fewer zones than the Regional Model. With fewer zones, it should likely require less aggregation/disaggregation allowing data to be more easily translated to/from the Integrated Model.

- The Sketch Plan model could more be used to represent the intervening year models since the more aggregated model would require less modification.

Based on these considerations, we would recommend that the development of the Sketch Plan model be closely coordinated with the development of the Integrated Model.

11. CONCLUSION & RECOMMENDATIONS

In this evaluation, we have concluded the following:

- Both the PECAS and URBANSIM model provide data and analysis suitable for many of the duties which SCAG performs. These models would be particularly useful in the development of demographic forecasts, which is a key task performed by SCAG.

- These models both integrate well with regional travel demand models, another key analysis tool utilized by SCAG.

- Both of these models are either being used or implemented at various MPOs and State Transportation Agencies in the United States.

- Each model has both advantages and disadvantages based on their features and design; therefore the selection of one or the other should be based on the needs of SCAG as it relates to each individual model.

- Regardless of the model eventually selected, significant efforts will be required to collect the necessary data including parcel data, land price data, zoning data, and other relevant items.

- Calibrating and running any integrated model will require significant staff and consultant resources and a commitment to a multi-year development process.

We therefore recommend the following:

- SCAG should commission a Model Design Study, which will establish detailed parameters for the model including zone size and possibly recommending the selection of one modeling platform (PECAS or URBANSIM) in the near future.

- SCAG should also begin the process to collect the necessary data for the Integrated Model.

- The development of the Integrated Model should be coordinated with the development of the Sketch Plan model, as the latter could facilitate the interface between the land use/transportation and transportation models.

- SCAG should also continue the process of coordinating with other large MPOs in the state and Caltrans that are developing Integrated Models. It is likely that their experience with Integrated Models will prove extremely helpful as SCAG moves forward with the process.

Appendix A

Table A-1 PECAS Evaluation

TABLE A-1
RECOMMENDED EVALUATION CRITERIA- PECAS

Category	Criteria	Reason	Performance	Mitigating Measures
Travel Demand Model	Compatibility With TransCAD Model	SCAG working on TransCAD model at this time, will be modeling platform used by SCAG for next 5-10 years. ILU Model should interface with TransCAD level on general inputs and outputs.	No evidence that PECAS is incompatible with TransCAD model at the theoretical level. Some adjustments to either model may be necessary to ensure that information is passed between the two models appropriately.	None required
	Compatibility with Activity Based Models	SCAG considering move to activity based models. ILU Model should have the potential to interface with an activity-based model at some level of general inputs and outputs.	PECAS theoretical structure is consistent with those used by activity based models.	None required
SCAG Duties	Ability to Forecast Housing Affordability	Identified in Needs Assessment as a major concern of SCAG staff. We expect housing affordability to be a major concern in the region for the next 15-20 years. ILU Model needs to be sensitive to the amount and location of affordable housing.	PECAS uses land use price data to determine supply and demand for future iterations. Housing affordability would be modeled in terms of the larger land price analysis which would include other land use categories.	None required
	Ability to analyze or provide outputs for Air Quality Analysis	Identified in Needs Assessment as a major concern of SCAG staff. We expect this issue to be a major concern in the region for the next 15-20 years. ILU Model should either output this information directly or interface with other models (travel demand model or air quality model) that performs the necessary calculations.	PECAS does not directly output information to an air quality model. Output would need to be made to either a travel demand model, which would provide the information directly or to a separate air quality model.	To allow the ILUTM to influence the air quality results, the inputs to the air quality model should be sensitive to land use changes. The most efficient method to do this is to use the ILUTM to prepare demographic forecasts, which are input into the Travel Demand Model and then into an air quality model.
	Ability to Analyze TOD Projects	Major policy endeavor for SCAG is Compass 2% project. Model should have some ability to analyze/forecast either individual TOD's or more general TOD strategies. We expect that TOD-type developments will be a major focus in region as transit facilities are expanded. Similar projects would include infill and redevelopment projects. ILU Model should analyze these types of projects either through sensitivity to factors which concentrate development in TOD areas or by direct manipulation of the land use inputs. We anticipate that a major use of the model will be in alternative or scenario testing	PECAS relies upon a variety of factors which influence location including travel impedances (time), land prices, and the availability of land. PECAS is not likely to reflect Smart Growth policies unless they are reflected in other factors. For example, a household's decision to locate at a TOD is based on a variety of considerations, including convenient access to transit and other related items. PECAS does not consider these other factors and uses market-related elements which can be quantified (travel time, land cost, etc).	Three alternatives exist to allow the PECAS model to reflect SMART growth policies. The first would be to modify the Space Development Module to reflect non-market choices. In this method, the market-based process could be tweaked to either include other characteristics or to simulate the effect of non-market factors. For example, land costs at TOD developments could be reduced to simulate promoting TOD development. A second method is to input

TABLE A-1
RECOMMENDED EVALUATION CRITERIA- PECAS

Category	Criteria	Reason	Performance	Mitigating Measures
		related to various Smart Growth proposals.	For infill and redevelopment projects, PECAS can more easily accommodate those projects through the land inventory. The land inventory reflects land which is available for use by future development. Infill and redevelopment sites would be included in the land available for development, thereby simulating the redevelopment process.	zoning data into the model as was the case for several users. Under this scenario, existing land would have an additional designation indicating that the land could redevelop into other uses. For example, an industrial parcel could have its zoning changed to allow the possibility of redevelopment into residential land, as might occur at a TOD site. A third method would be to use the PECAS model to test alternatives where the model output is modified to reflect different policy choices.
	Ability to Forecast/Analyze Goods Movement	Goods Movement is a priority for SCAG as evidenced by previous and on-going studies. We expect this focus to remain in the future. Freight is a significant issue in the region with various ports, airports, rail, and truck facilities. One important aspect to freight is secondary distribution (what happens after freight arrives at a warehouse or distribution center. ILU should have a strong freight component and allow the analysis of various issues related to the freight.	Goods movement is considered a main area of strength for PECAS. The model explicitly tracks the movements of goods and people.	None required
	Ability to reflect market and exogenous forces	ILU should be sensitive to market forces like rents, home sales trends, water and school capacity, as well as exogenous events, such as major shifts in the economy, fuel prices, new regulatory requirements, availability of investment capital, and other factors.	The model structure does not explicitly account for these elements except where these factors are included in the travel demand model. For example, changes in fuel prices could be reflected in the travel demand model and would also be reflected in the ILUTM. Other factors not included in the travel demand model would not be reflected in the ILUTM. The information would be reflect in the model only to the extent that they reflect future zoning.	For those elements not included in the travel demand model, changes to the Space Development Module would be required. One potential change could include altering the process by which land is designated as available for development. You could also make off-line changes to a future market scenario to test alternatives (as in the case of Smart Growth policies described above).
	Ability to provide demographic forecasts	A key task for SCAG is developing demographic forecasts which are inputs to a variety of planning studies such as the Travel Demand Model, the Regional Transportation Plan, and	These kinds of forecasts are a basic function of the PECAS model.	None required.

TABLE A-1
RECOMMENDED EVALUATION CRITERIA- PECAS

Category	Criteria	Reason	Performance	Mitigating Measures
		other related items. The model should be able to either to provide the demographic forecasts directly or provide input on the forecasting process.		
	Model sensitivity to policies and planning assumptions at the regional level	The ILU should be sensitive to major regional policy directions and regional assumptions. For example, SCAG may set regional population caps for counties or other areas within the model based on the application of other methods.	The model structure does not explicitly account for these elements except where these factors are included in the travel demand model or as a result of zoning changes.	For those changes not reflected in either the travel model or zoning, changes to the model would likely have to be made off-line or through global adjustments to the various parameters used by the model. For example, if SCAG staff wanted to incorporate county population caps, the following process would have to be used. 1.) The model would be run, 2.) The results would be compared against the expected results, and 3.) The model input data would need to be revised.
Model Structure	Level of GIS Integration	Integration with GIS is a key element. This integration would include the use of GIS system to develop input data and GIS to output the data as well.	The PECAS model interfaces with GIS systems at both the input and output level.	None required
	Ability to Work at Different Scales	This criteria reflects two concerns. First, the model may have zones of varying sizes which could range from the City level to the travel model TAZ level or smaller. Second, the model may be applied to various planning studies which could be regional or at the local city level. Implementation of the model is likely to occur in a phased approach whereby the model is initially built at a more aggregate geographic scale and then further refinement is made.	PECAS processes data at two levels. Much of the land use analysis is done at the parcel level while the analysis of accessibility is done at the traffic analysis zone (TAZ) level. Zones larger than the TAZ level are permissible as long at the ILUTM zones are aggregations of the TAZ's. The only limitation is that PECAS currently has a zone limit of 750 zones, which mostly derives from limitations in the current generation of computers. This limit could change with advances in both hardware and software. This geographic flexibility lends itself to a phased implementation. For example, the initial model could be limited to only 150 zones to test the model processes and structure. After that, a more complex model could be implemented using the same data. For example, a	None required.

TABLE A-1
RECOMMENDED EVALUATION CRITERIA- PECAS

Category	Criteria	Reason	Performance	Mitigating Measures
			500 zone model could be implemented later once the smaller model is working appropriately. Caltrans is currently implementing a PECAS model for the state of California and is proposing to do so in a phased approach.	
Implementation and Maintenance	Vendor Support	SCAG will need significant support from the vendor in implementing model. We will consider the experience of other agencies when evaluating the ability of each vendor to support their project. If the vendor is unable to support the software at a high level, additional consultant support would be needed.	The perception among the community of land use model users is that PECAS is not supported as heavily as other integrated models. Much of the support at MPO's occurs through peer-level support or through hiring of outside consultants.	SCAG staff should not expect a significant level of support from the PECAS developer. Additional in-house staff, outside consultants, and other options will have to be considered.
	Ease of Modification	The model should be relatively easy to modify. The ease of modification depends on whether the model source code is available or whether there are other methods used to modify the model elements.	PECAS is an open code model. Users can modify the model coding as needed for their purposes.	None required
	Budget Requirement and Staff Resources	This criteria assesses the cost of implementing an Integrated Model and whether one model requires substantially less resources (staff and overall budget) than the other.	Implementing a PECAS level model will require significant efforts by SCAG including to collect the necessary data and develop the model. We anticipate the data collection to be a significant expenditure.	None required
	Use by Other California Jurisdictions	Much of the LU model support is done at the peer-group level. Use of a model that will be used by other MPO's and agencies in California will allow SCAG staff to tap into their experience in apply and developing the model.	PECAS being implemented in Sacramento and as a statewide model by Caltrans. PECAS may be implemented by SANDAG as well.	None required
	Data Requirements	Data requirements between models could vary in terms of data availability, scale, flexibility, processing, and cost. A model would be rate higher if the data could be more easily obtained, if less data collection was required because the model used data already collected by SCAG, or if there was a significant difference in the level of data required.	The PECAS model will require significant data collection, including detailed land use data at the parcel level. Another significant element will include data related to land prices, which is a key function of the model.	If the PECAS model is adopted, a significant amount of data will have to be collected.

Source: Fehr & Peers, 2007

Appendix B

Table A-2 URBANSIM Evaluation

TABLE A-2
RECOMMENDED EVALUATION CRITERIA- URBANSIM

Category	Criteria	Reason	Performance	Mitigating Measures
Travel Demand Model	Compatibility With TransCAD Model	SCAG working on TransCAD model at this time, will be modeling platform used by SCAG for next 5-10 years. ILU Model should interface with TransCAD level on general inputs and outputs.	No evidence that URBANSIM is incompatible with TransCAD model at the theoretical level. Some adjustments to either model may be necessary to ensure that information is passed between the two models appropriately.	None required
	Compatibility with Activity Based Models	SCAG considering move to activity based models. ILU Model should have the potential to interface with an activity-based model at some level of general inputs and outputs.	URBANSIM's structure is not consistent with an activity based model. URBANSIM does not explicitly track the movement of persons and goods, which is a key element of an activity based model.	URBANSIM model would have to be modified to be consistent with activity based model. The level of this modification and whether it can even be done is unknown at this time.
SCAG Duties	Ability to Forecast Housing Affordability	Identified in Needs Assessment as a major concern of SCAG staff. We expect housing affordability to be a major concern in the region for the next 15-20 years. ILU Model needs to be sensitive to the amount and location of affordable housing.	URBANSIM uses land use price data to determine supply and demand for future iterations. Housing affordability would be modeled in terms of the larger land price analysis which would include other land use categories.	None required
	Ability to analyze or provide outputs for Air Quality Analysis	Identified in Needs Assessment as a major concern of SCAG staff. We expect this issue to be a major concern in the region for the next 15-20 years. ILU Model should either output this information directly or interface with other models (travel demand model or air quality model) that performs the necessary calculations.	URBANSIM does not directly output information to an air quality model. Output would need to be made to either a travel demand model, which would provide the information directly or to a separate air quality model.	To allow the ILUTM to influence the air quality results, the inputs to the air quality model should be sensitive to land use changes. The most efficient method to do this is to use the ILUTM to prepare demographic forecasts, which are input into the Travel Demand Model and then into an air quality model.
	Ability to Analyze TOD Projects	Major policy endeavor for SCAG is Compass 2% project. Model should have some ability to analyze/forecast either individual TOD's or more general TOD strategies. We expect that TOD-type developments will be a major focus in region as transit facilities are expanded. Similar projects would include infill and redevelopment projects. ILU Model should analyze	URBANSIM relies upon a variety of factors which influence location including population and employment forecasts, regulatory restrictions, and impedances from the travel demand model. SMART growth policies could be reflected in the model most directly through changes to the regulatory policies. Infill and other	Model inputs would have to be adjusted to indirectly reflect these items. Most likely changes would be the regional growth forecasts and the regulatory overlays.

TABLE A-2
RECOMMENDED EVALUATION CRITERIA- URBANSIM

Category	Criteria	Reason	Performance	Mitigating Measures
		these types of projects either through sensitivity to factors which concentrate development in TOD areas or by direct manipulation of the land use inputs. We anticipate that a major use of the model will be in alternative or scenario testing related to various Smart Growth proposals.	redevelopment could also be input through changes in the regulatory restrictions. The effect of these policies would also be reflected through the population and employment forecasts which are input directly into the model.	
	Ability to Forecast/Analyze Goods Movement	Goods Movement is a priority for SCAG as evidenced by previous and on-going studies. We expect this focus to remain in the future. Freight is a significant issue in the region with various ports, airports, rail, and truck facilities. One important aspect to freight is secondary distribution (what happens after freight arrives at a warehouse or distribution center. ILU should have a strong freight component and allow the analysis of various issues related to the freight.	Goods movement not explicitly addressed by URBANSIM. URBANSIM does not track the flow of goods or freight.	To incorporate this feature, a dedicated freight model would be required.
	Ability to reflect market and exogenous forces	ILU should be sensitive to market forces like rents, home sales trends, water and school capacity, as well as exogenous events, such as major shifts in the economy, fuel prices, new regulatory requirements, availability of investment capital, and other factors.	These factors could be reflected in the model only to the extent that inputs were changed. The most likely changes would be reflected in the population and employment forecasts. Other changes could be done so through regulatory restrictions.	Model inputs would have to be adjusted to indirectly reflect these items. Most likely changes would be the regional growth forecasts and the regulatory overlays.
	Ability to provide demographic forecasts	A key task for SCAG is developing demographic forecasts which are inputs to a variety of planning studies such as the Travel Demand Model, the Regional Transportation Plan, and other related items. The model should be able to either to provide the demographic forecasts directly or provide input on the forecasting process.	The larger scale forecasts would be input into the URBANSIM model. The allocation of these forecasts to the sub-areas would be one of the outputs to the model.	None required.
	Model sensitivity to policies and planning assumptions at the regional level	The ILU should be sensitive to major regional policy directions and regional assumptions. For example, SCAG may set regional population caps for counties or other areas within the model based on the application of other methods.	URBANSIM incorporates policy limitations into the land use allocation process. SCAG could input these limitations such as growth caps and the model would allocate the future development to reflect these limitations.	Model would not produce the larger regional forecasts but would provide detailed allocations to the geographic sub-units (cities and below).
Model Structure	Level of GIS Integration	Integration with GIS is a key element. This integration would include the use of GIS system to develop input data and GIS to output the data as well.	The URBANSIM model interfaces with GIS systems at both the input and output level. Anecdotal evidence suggests that the output process is relatively easy to	None required

TABLE A-2
RECOMMENDED EVALUATION CRITERIA- URBANSIM

Category	Criteria	Reason	Performance	Mitigating Measures
			implement.	
	Ability to Work at Different Scales	This criteria reflects two concerns. First, the model may have zones of varying sizes which could range from the City level to the travel model TAZ level or smaller. Second, the model may be applied to various planning studies which could be regional or at the local city level. Implementation of the model is likely to occur in a phased approach whereby the model is initially built at a more aggregate geographic scale and then further refinement is made.	The URBANSIM model can also operate at a variety of geographic scales. The zones would need to reflective of the travel demand model with some relationship between the TAZ's and the land use model zones. For example, it is permissible for the land use model zones to be an aggregation of the TAZ's used by the travel model. However, it would be more difficult to implement the model at a phased approach if the data is maintained at the zonal level instead of the parcel level. It is likely that the land use data would be maintained at the parcel level, as was the case with the Salt Lake City MPO.	None required.
Implementation and Maintenance	Vendor Support	SCAG will need significant support from the vendor in implementing model. We will consider the experience of other agencies when evaluating the ability of each vendor to support their project. If the vendor is unable to support the software at a high level, additional consultant support would be needed.	URBANSIM has a reputation of better vendor support. One of the Delphi Panelists noted this in his response.	None required
	Ease of Modification	The model should be relatively easy to modify. The ease of modification depends on whether the model source code is available or whether there are other methods used to modify the model elements.	URBANSIM is open source software and the software developers encourage the user to modify the code for their purpose and share their modifications with other users. URBANSIM has the reputation of being easier to modify than other available platforms. One of the Delphi Panelists noted this in his response.	None required
	Budget Requirement and Staff Resources	This criteria assesses the cost of implementing an Integrated Model and whether one model requires substantially less resources (staff and overall budget) than the other.	Implementing an URBANSIM model by SCAG would require significant efforts and expenditures of funds for data collection and model development.	None required
	Use by Other California Jurisdictions	Much of the LU model support is done at the peer-group level. Use of a model that will be used by other MPO's and agencies in California will allow SCAG staff to tap into their experience in apply and developing the model.	There are other agencies that are implementing URBANSIM but none in California	Since there would be limited peer-level support, additional outside support would be needed.

TABLE A-2
RECOMMENDED EVALUATION CRITERIA- URBANSIM

Category	Criteria	Reason	Performance	Mitigating Measures
	Data Requirements	Data requirements between models could vary in terms of data availability, scale, flexibility, processing, and cost. A model would be rate higher if the data could be more easily obtained, if less data collection was required because the model used data already collected by SCAG, or if there was a significant difference in the level of data required.	Most of the data required for an URBANSIM model would relate to land use data, much of which is data that is traditionally available (number of households, population, etc) or could be extracted from a parcel database with additional manipulation. The URBANSIM model would require additional data related to land value, regulatory restrictions, and data regarding vacancy.	If the URBANSIM model is adopted, a significant amount of data will have to be collected.

Source: Fehr & Peers, 2007

Appendix C

Table A-3 Comparison of URBANSIM & PECAS

TABLE A-3
RECOMMENDED EVALUATION CRITERIA- SUMMARY

Category	Criteria	PECAS	URBANSIM	ADVANTAGE
Travel Demand Model	Compatibility With TransCAD Model	No evidence that PECAS is incompatible with TransCAD model at the theoretical level. Some adjustments to either model may be necessary to ensure that information is passed between the two models appropriately.	No evidence that URBANSIM is incompatible with TransCAD model at the theoretical level. Some adjustments to either model may be necessary to ensure that information is passed between the two models appropriately.	*Neither- Both models compatible with TransCAD model.*
	Compatibility with Activity Based Models	PECAS theoretical structure is consistent with those used by activity based models.	URBANSIM's structure is not consistent with an activity based model. URBANSIM does not explicitly track the movement of persons and goods, which is a key element of an activity based model.	**PECAS- Model structure similar to activity based model**
SCAG Duties	Ability to Forecast Housing Affordability	PECAS uses land use price data to determine supply and demand for future iterations. Housing affordability would be modeled in terms of the larger land price analysis which would include other land use categories.	URBANSIM uses land use price data to determine supply and demand for future iterations. Housing affordability would be modeled in terms of the larger land price analysis which would include other land use categories.	*Neither- Both models include price data which can be influenced to reflect differing levels of housing affordability*
	Ability to analyze or provide outputs for Air Quality Analysis	PECAS does not directly output information to an air quality model. Output would need to be made to either a travel demand model, which would provide the information directly or to a separate air quality model.	URBANSIM does not directly output information to an air quality model. Output would need to be made to either a travel demand model, which would provide the information directly or to a separate air quality model.	*Neither- Both models do not directly outputs air quality indicators. Both models would have to be used as inputs into Travel Demand and Air Quality models.*
	Ability to Analyze TOD Projects	PECAS relies upon a variety of factors which influence location including travel impedances (time), land prices, and the availability of land. PECAS is not likely to reflect Smart Growth policies unless they are reflected in other factors. For example, a household's decision to locate at a TOD is based on a variety of considerations, including convenient access to transit and other related items.	URBANSIM relies upon a variety of factors which influence location including population and employment forecasts, regulatory restrictions, and impedances from the travel demand model. SMART growth policies could be reflected in the model most directly through changes to the regulatory policies. Infill and	*Neither- Both models would have to be adjusted to reflect Smart Growth polices.*

TABLE A-3
RECOMMENDED EVALUATION CRITERIA- SUMMARY

Category	Criteria	PECAS	URBANSIM	ADVANTAGE
		PECAS does not consider these other factors and uses market-related elements which can be quantified (travel time, land cost, etc). For infill and redevelopment projects, PECAS can more easily accommodate those projects through the land inventory. The land inventory reflects land which is available for use by future development. Infill and redevelopment sites would be included in the land available for development, thereby simulating the redevelopment process.	other redevelopment could also be input through changes in the regulatory restrictions. The effect of these policies would also be reflected through the population and employment forecasts which are input directly into the model.	
	Ability to Forecast/Analyze Goods Movement	Goods movement is considered a main area of strength for PECAS. The model explicitly tracks the movements of goods and people.	Goods movement not explicitly addressed by URBANSIM. URBANSIM does not track the flow of goods or freight.	**PECAS- Explicitly tracks movement of goods.**
	Ability to reflect market and exogenous forces	The model structure does not explicitly account for these elements except where these factors are included in the travel demand model. For example, changes in fuel prices could be reflected in the travel demand model and would also be reflected in the ILUTM. Other factors not included in the travel demand model would not be reflected in the ILUTM. The information would be reflect in the model only to the extent that they reflect future zoning.	These factors could be reflected in the model only to the extent that inputs were changed. The most likely changes would be reflected in the population and employment forecasts. Other changes could be done so through regulatory restrictions.	*Neither- Both models operate on land use based inputs and do not explicitly account for these types of factors. These changes could be reflected in regulatory inputs, which can be added to the model.*
	Ability to provide demographic forecasts	These kinds of forecasts are a basic function of the PECAS model.	The larger scale forecasts would be input into the URBANSIM model. The allocation of these forecasts to the sub-areas would be one of the outputs to the model.	*Neither- Both models would produce demographic forecasts.*
	Model sensitivity to policies and planning assumptions at the regional level	The model structure does not explicitly account for these elements except where these factors are included in the travel demand model or as a result of zoning changes.	URBANSIM incorporates policy limitations into the land use allocation process. SCAG could input these limitations such as growth caps and the model would allocate the future development to reflect these limitations.	**URBANSIM- This information is directly input into the model. The PECAS model does not contain a mechanism to incorporate these constraint factors.**
Model Structure	Level of GIS Integration	The PECAS model would interface with GIS systems at the input and output level. Much of the analysis is done at the	The URBANSIM model interfaces with GIS systems at both the input and output level.	*Neither- Both models interface with GIS at input/output level.*

TABLE A-3
RECOMMENDED EVALUATION CRITERIA- SUMMARY

Category	Criteria	PECAS	URBANSIM	ADVANTAGE
		parcel level, which would be maintained in a GIS system. There is some anecdotal evidence from other PECAS users that the output process to a GIS can be	Anecdotal evidence suggests that the output process is relatively easy to implement.	
	Ability to Work at Different Scales	PECAS processes data at two levels. Much of the land use analysis is done at the parcel level while the analysis of accessibility is done at the traffic analysis zone (TAZ) level. Zones larger than the TAZ level are permissible as long at the ILUTM zones are aggregations of the TAZ's. The only limitation is that PECAS currently has a zone limit of 750 zones, which mostly derives from limitations in the current generation of computers. This limit could change with advances in both hardware and software. This geographic flexibility lends itself to a phased implementation. For example, the initial model could be limited to only 150 zones to test the model processes and structure. After that, a more complex model could be implemented using the same data. For example, a 500 zone model could be implemented later once the smaller model is working appropriately. Caltrans is currently implementing a PECAS model for the state of California and is proposing to do so in a phased approach.	The URBANSIM model can also operate at a variety of geographic scales. The zones would need to reflective of the travel demand model with some relationship between the TAZ's and the land use model zones. For example, it is permissible for the land use model zones to be an aggregation of the TAZ's used by the travel model. However, it would be more difficult to implement the model at a phased approach if the data is maintained at the zonal level instead of the parcel level. It is likely that the land use data would be maintained at the parcel level, as was the case with the Salt Lake City MPO.	*Neither- Both models can operate at a variety of scales.*
Implementation and Maintenance	Vendor Support	The perception among the community of land use model users is that PECAS is not supported as heavily as other integrated models. Much of the support at MPO's occurs through peer-level support or through hiring of outside consultants.	URBANSIM has a reputation of better vendor support. One of the Delphi Panelists noted this in his response.	**URBANSIM- Anecdotal evidence suggests that URBANSIM users receive higher level of support.**
	Ease of Modification	PECAS is an open code model. Users can modify the model coding as needed for their purposes.	URBANSIM is open source software and the software developers encourage the user to modify the code for their purpose and share their modifications with other users. URBANSIM has the reputation of being easier to modify than other available platforms. One of the Delphi Panelists noted this in his	**URBANSIM-Source code for both models can be adjusted but evidence is that URBANSIM is easier to modify**

TABLE A-3
RECOMMENDED EVALUATION CRITERIA- SUMMARY

Category	Criteria	PECAS	URBANSIM	ADVANTAGE
			response.	
	Budget Requirement and Staff Resources	Implementing a PECAS level model will require significant efforts by SCAG including to collect the necessary data and develop the model. We anticipate the data collection to be a significant expenditure.	Implementing an URBANSIM model by SCAG would require significant efforts and expenditures of funds for data collection and model development.	*Neither- Both models will require a significant expenditure of funds for data collection, model development, and running the model.*
	Use by Other California Jurisdictions	PECAS being implemented in Sacramento and as a statewide model by Caltrans. PECAS may be implemented by SANDAG as well.	There are other agencies that are implementing URBANSIM but none in California	**PECAS- PECAS model being implemented by SACOG and Caltrans.**
	Data Requirements	The PECAS model will require significant data collection, including detailed land use data at the parcel level. Another significant element will include data related to land prices, which is a key function of the model. To properly calibrate the model, historical data would be required.	Most of the data required for an URBANSIM model would relate to land use data, much of which is data that is traditionally available (number of households, population, etc) or could be extracted from a parcel database with additional manipulation. The URBANSIM model would require additional data related to land value, regulatory restrictions, and data regarding vacancy. To calibrate the model, historical data would be required.	*Neither-Both models will require the collection of a significant amount of land use information. It is likely that PECAS will require more detailed land use data since that model uses more detailed land use categories than URBANSIM.*

Note: Advantages for PECAS highlighted in blue, URBANSIM in red
Source: Fehr & Peers, 2007