Review of Land Use Models
Draft

Prepared for
Atlanta Regional Commission

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1. Introduction

The use of population and employment forecasts is critical to the planning process conducted by the Atlanta Regional Commission. The forecasts are used to support a variety of activities from the development of transportation, environmental and land use plans to the analysis of developments of regional significance. The Atlanta Regional Commission currently produces forecasts of population, households by income, employment by industry and land use by type for the 20 county area using a two-step procedure. First a control forecast is produced for the entire region using the Interactive Population and Econometric Forecasting (IPEF) model. This control forecast is then disaggregated to census tracts using the Disaggregated Residential Allocation Model/Employment Allocation (DRAM/EMPAL) model. The socio-economic forecasts are produced using an iterative process linked with the MPO's travel demand model. ARC switched from EMPIRIC to DRAM/EMPAL in the mid-1990's. At the time, DRAM/EMPAL was the only available computerized land use model that had a link to travel demand models. Since that time, the development of land use models has changed dramatically with the advancement of personal computers, the collection and analysis of data at small levels of detail and the implementation of Geographic Interactive Spatial (GIS) procedures for review and analysis.

In addition, the requirements for the development of travel demand models which are utilized to develop regional transportation plans have also changed dramatically with the implementation of the federal legislation. As a result, all elements of the travel demand modeling process have been designed to support all technical and policy decisions that are required in developing a comprehensive, multimodal transportation plan and program in accordance with the Intermodal Surface Transportation Equity Act of 1991 (ISTEA), the 1990 Clean Air Act Amendments (CAAA) and the Transportation Conformity Rule and the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Travel demand model improvements over the past decade and a half have generally been incremental approaches designed to produce a process that successfully addresses all federal planning and air quality requirements and sufficiently represents all transportation modes in the Atlanta region.

The purpose of this effort was to collect information on the status of land use models around the country. There were two key activities to this effort. First, a review of the literature on the application and development of land use models was conducted to collect information on the structure and data requirements for the land use models currently in use or development. Then, peer MPOs were surveyed to collect information on their current models to develop forecasts, their satisfaction/dissatisfaction with the models and their future plans for their land use models. A telephone survey was conducted of the following metropolitan

planning organizations (MPOs) that are considered to be national leaders in land use modeling.

- Baltimore Metropolitan Commission (BMC)
- Denver Regional Council of Governments (DRCOG)
- Houston-Galveston Area Council (H_GAC)
- Portland Metro (Metro)
- Puget Sound Regional Commission (PSRC)
- Sacramento Area Council of Governments (SACOG)
- Washington Council of Governments (WACOG)

Then a technical evaluation of the MPO interviews was prepared based on the criteria outlined in the literature review. The results from the survey of the MPOs and the technical evaluation of the interviews are summarized in this document. A separate technical appendix*, Summary of Land Use Model Research* has also been prepared which contains the literature review and the detailed responses from the MPO interviews.

2. Survey of Metropolitan Planning Organizations

The survey was sent to the interviewees before the telephone survey was conducted so they knew what information was being requested. This survey was targeting more policy level questions than technical detail, that is, the objective of the survey was to gauge the reasons why the MPOs were undertaking their current approach toward land use modeling, and their general sense on the value of such efforts. The questions focused on the following areas of interest.

- General Background on the Development and Uses of the Forecasts
- Current Model
- Future Model
- Summary of General Information of the MPO area (pop, number of traffic analysis zones, size)

The results of this survey are organized below by the questions that were asked in the survey. In most cases, the answers are synthesized from all seven responses; more specific information (including technical reports) is available in the individual MPO interview responses which are contained in the Technical Appendix. For purposes of presentation, the respondents are referred to by their MPO designation, for example, "Portland Metro noted…."

After the initial survey responses were summarized, follow-up questions were asked of each MPO in order to get clarification and some technical information related to the modeling questions 9 through 15. WACOG was not asked follow-up questions because they have no land use model and no plans to implement one. For the five other MPOs, the questions and answers are included below, with questions indicated by "Technical Follow-up" and answers indicated by "Answer", sometimes with the initials of the person providing the answer. BMC did not respond to calls or emails, and so only their questions are shown below.

2.1 MPO Survey Responses

General Background

1. **Please describe briefly the history of land use modeling in your agency. When was the first land use model used? When was the current model adopted? If you have switched to a new land use model in the past five years, what is your estimate of the financial and staff resource costs associated with this switch?**

   Given the often lengthy descriptions provided by the MPOs, the individual responses are found in the Section?

2. **Which unit in your organization is responsible for developing and using your land use model? How many full-time staff equivalents are in this unit? What is your estimate of the land use modeling portion of your agency's transportation planning budget (or overall agency budget if the forecasting function is in another agency unit)?**

   BMC: *The development and support of the land use model is a shared responsibility within BMC. A "Data Development" group develops the model and collects the data. A "Technical Modeling" group actually uses the model in the transportation planning efforts. BMC estimates that 2.5 FTE's are dedicated to the land use modeling effort, representing approximately 5% of the transportation planning budget.*

   DRCOG: *The unit responsible for all modeling in DRCOG is the Regional Modeling group, which does both land use and transportation demand modeling. Up to two years ago, land use modeling was done in a separate unit (economics), but with the retirement of a key staff person, DRCOG decided to restructure its modeling efforts. In addition, they thought it was a good time to integrate more fully the land use and transportation efforts.*

   There are approximately 12 people in the unit, with 5 to 6 devoted to modeling. About 2 FTE's are devoted to land use modeling, out of 90 to 100 FTE's in the organization.

   H-GAC: *The unit responsible for land use modeling is the Community and Environmental Planning Division. They receive most of their funding support from the transportation planning group. There are about 3 FTE's (5 percent of transportation planning budget) devoted to land use modeling.*

   Metro: *The DRC (Data Resource Center – GIS section of Metro Planning) is the unit responsible. The DRC consists of 13.5*

FTE involved principally in GIS work. The forecast/data analysis/land use modeling/code support group consists of 3.8 FTE providing regional forecasting, land use modeling, data analysis and systems development services. The budget for this section amounts to approximately $1.5 million with professional services and M & S.

PSRC: PSRC has about 20 FTEs for its entire data analysis capability. Its $810,000 budget represents less than 5% of the agency budget.

SACOG: The unit responsible for land use modeling is the Research and Analysis group headed by Gordon. They are responsible for data, travel demand modeling and GIS. There are approximately 7 staff members in this group, with the group's budget representing about 20 to 30% of the agency's budget ($2 to $3 million out of $10 million).

WACOG: The COG prepares the land use forecasts and then gives them to the Transportation Planning Board (the officially designated MPO) for use in the transportation planning process. The MPO group responsible of using the land use forecasts in TPB is called the Data and Technical Services Group, which has about 10 FTE's, of which two are devoted to land use analysis. However, the TPB is also funding the COG's land use staff to do the regional forecasts. The total budget for the land use portion of the effort is about $660,000, 5% of the work program. This includes supporting the staff time in the planning group to use the land use forecasts in travel demand modeling.

3. How often are land use forecasts produced? How does this schedule link to the transportation planning cycle?

BMC: Land use forecasts are updated each year, primarily because they do plan conformity analysis every year.

DRCOG: Every year, DRCOG does some update work to its land use database. For example, the regional development plan, METROVISION, has adopted an "urban centers" concept. Every year, some community comes to DRCOG to incorporate another urban center into the regional database, which causes the data base to be changed. Land use forecasts are updated fully every 2 to 3 years corresponding to the transportation plan update.

H-GAC: Land use forecasts are synchronized with the transportation planning cycle. The forecasts are done one year prior to the transportation planning analysis.

Metro: *Metro does 2 to 10 MetroScope runs per year for a variety of reasons ranging from policy analysis for the entire region (the regional plan update is titled "the New Look") to corridor studies. The "official forecast" on which the RTP is based and our State required "Urban Growth Report" to determine UGB size we update with the land use model every 5 years (the jurisdiction review process takes at least a year).*

PSRC: *The land use forecasts are updated every 3 or 4 years, starting from "scratch." These forecasts are done prior to the network analysis for the transportation plan update.*

SACOG: *the plan update is done every three years, but they are now on a five-year cycle because they had a plan lapse finding, which put the plan process into a 15 month limbo. An interim plan was put in place, and a new plan has restored the regular cycle. They expect to adopt the SAFETEA-LU four-year cycle for plan updates.*

WACOG: *Every effort is made to coordinate the land use forecasts with the transportation planning process. There is a major transportation plan update every three years. As a practical matter, the land use data base and transportation model are updated every year because of new projects being brought into the mix (the latest being the Intercounty Connector). With such new projects, local jurisdictions are asked to revise their TAZ forecasts if reasonable. Thus, for example, D.C. did revise downward some of their TAZ forecasts with the Intercounty Connector (in MD) because it was expected to draw development away from some sections of D.C.*

4. How important are the results of land use forecasting in the transportation decision making process in your agency?

Perhaps due to the audience being interviewed, all the MPOs concluded that land use modeling results are very important in the decision making process in their agency. SACOG noted that the transportation plan for the region is likely to have 50% devoted to land use strategies and 50% focused on traditional transportation investment (and thus the need for good land use modeling).

H-GAC observed that the level of interest on the part of decision makers varies by topic. There seems to be very intense interest in the regional and county control values ("Look how much we have grown!"). The fact that many local agencies provide feedback on county level data suggests that the forecasts are of interest at this level as well. So, decision maker interest is found primarily at the "big picture" level. There is much less discussion on the types and character of

development needs and such things as mixed use development, protection of critical habitats, etc.

In Portland, Metro is "sensitive to ensuring that land use planning produces land uses more compatible with proposed transportation projects given that MetroScope indicates that transportation projects may change land use intensities and trip making behavior. (For instance, Metro councilors are insisting that a street car line going through an industrial district be accompanied with an upzone of the district to allow a range of uses, MetroScope indicates would be viable in the area.)"

5. Are the land use forecasts used for any purpose in your agency other than transportation planning (e.g., water resource planning)?

In most cases, the forecasts were used for other purposes.

BMC:	*Reservoir planning* *Emergency management*
DRCOG:	*Regional water resource planning (another agency)* *Hope to use for aging studies in the future*
H-GAC:	*Aging, FEMA, flood control, landfill siting, and job training. The forecasts are the beginning point of these planning processes. H-GAC is not at all comfortable having different units within H-GAC using different forecasts.*
Metro:	*Urban growth boundary planning, central facilities planning (fire stations, health facilities, schools, etc.), affordable housing, water/sewer demand forecasting, regional land use planning policy, economic development planning.*
PSRC:	*Local jurisdictions use forecasts to comply with state's growth management mandates.*
SACOG:	*Affordable housing (forecast year 2011);* *Air Quality Management District for the SIP update* *Flood protection planning of the agency*
WACOG:	*COG forecasts are used for all planning activities, especially water resource planning.* *.*

6. How are state or other cooperating agencies (e.g., transit agencies) involved in your land use modeling efforts?

In many cases, a state agency (e.g., Department of Finance, or Revenue, or Community Affairs, Water Planning Board) produces state and county-level control values for population and employment. Interestingly, in almost every case, however, these values are

"considered", but not adopted by the MPO, and as noted by several MPOs, these values are often viewed with suspicion. The one exception to this was Portland Metro (most likely due to their growth management legacy) where they "worked closely with the State in coordinating the regional forecast with the State forecast and also we anticipate working with the State in insuring consistency between the State land use model and the region's model."

Several MPOs use panels or committees to examine different land use forecasts to try to reconcile any differences. DRCOG, for example, convenes a panel of local experts (including the state Department of Local Affairs, which does its own forecasting) to form a consensus on the validity of the forecasts. However, as noted by DRCOG, it "vehemently" does not accept forecasts that are done exogenously of its process.

Texas has a state law that enables jurisdictions to form local economic development tax districts (with local option taxes) usually done at the county level. These districts, of which there are several, usually hire consultants to develop their own development forecasts, and H-GAC believes that these forecasts tend to be a bit optimistic. To their knowledge, these districts do not use H-GAC's forecasts.

Every MPO stated that their regional transit district uses the forecasts for alternatives analyses, and in some cases, development scenarios that reflect potential development benefits from transit investment (TOD).

7. How are local governments involved in your land use modeling efforts? Do they provide data or forecasts of their own? Do they review the forecasts produced by your agency? Do they have to approve these forecasts? Are they required by state law to use your forecasts for their own planning efforts?

Heavy involvement of local governments in land use modeling and in the use of the forecasts was very much a characteristic of almost all the MPOs.

BMC: Local officials pay attention to the land use forecasts. They sign off on the inputs that go into these forecasts (at least the inputs they provide). Local officials do not hesitate to complain about the forecasts if they do not like them. No law requiring their participation.

DRCOG: Local governments do review DRCOG forecasts and proactively work with DRCOG if there are discrepancies. Local governments provide estimates of households and employment by TAZ. DRCOG treats these as a "capacity threshold" for the TAZ's, that is, the levels of population and employment that might happen in each zone. Last year,

DRCOG did an analysis of all the population and employment estimates offered by local governments and/or found in their comprehensive plans and compared the sum of these estimates to their own forecast. The locals' sum was 10 to 15% higher than the regional total for households, and more than twice as large for employment.

H-GAC: *H-GAC receives "significant" comments from local governments on the forecasts. Usually, these comments offer new developments that the local governments are expecting in their jurisdiction. H-GAC has very strong developer contacts, and continually reviews platting activity to keep abreast of what is happening at the local level. H-GAC has received input from localities that recommends more growth than what is in the local land use plan.*

Metro: *All of Metro's (27 jurisdictions) participate in the review of MetroScope output in preparing the "official" RTP forecast. Besides output, jurisdictions review input assumptions regarding land capacity such as zoning, vacant acres, redevelopment and infill capacity and urban renewal assumptions. Local governments are responsible to take the MetroScope data at the control zone (72 E-zones and 425 R-zones) level and allocate the growth to the 2029 TAZ system. The growth management law requires jurisdictions to use the forecasts for decisions relating to the expansion of the urban growth boundary.*

PSRC: *Member jurisdictions provide data, and review forecasts and the input data for the forecasting process. However, they do not officially approve the data.*

SACOG: *SACOG went out to the locals and asked them to provide their "locally preferred land use alternative." Local governments provide what they consider to be the likely development futures for their community, and these are used in PLACES and will be used in PECAS. SACOG will be adopting a new plan in June 2007, and it is not yet clear how local governments will be asked to agree to the land use forecasts that are going to be in the plan. That is, how will they buy into the "most likely future" scenario? A lot of local agencies use the forecasts for "guideposts" in their local planning activities. For example, many school districts use the forecasts for planning future school enrollments. As local governments update their comprehensive plans, many have adopted SACOG's forecasts, whereas others have decided to do their own.*

WACOG: The bottom up part of the process is that local jurisdictions, that is, the same people who sit on the cooperative forecasting subcommittee develop their own jurisdiction's small area and TAZ forecasts. They look at building permits, development patterns, etc, and provide to COG the TAZ –level estimates. Thus, there is no land use model used at the regional level to distribute population and employment forecasts. They are not required by state law to use the forecasts, but obviously given that they developed them, they do use them.

8. Has your MPO adopted land use or development policies that have been modeled with your land use model (e.g. transit oriented development, town centered development, etc.)?

BMC: No, although they have done some simple scenario analyses.

DRCOG: The land use model clearly helped decision making in the development of METROVISION. Thus, with respect to the relationship to the transportation plan, the influence of land use modeling is indirect, but powerful. Also, DRCOG has adopted a well specified set of criteria for selecting projects for the TIP, some of which relate to the level of conformance of proposed projects with the METROVISION plan.

H-GAC: H-GAC has not adopted any official land use or development policies.

Metro: The present BASE CASE run explicitly models all land use plans, urban renewal investment strategies, TOD's and transportation levels of service and anticipated future investment that the region has in place along with state rules on urban growth boundary expansion and relevant state and federal requirements for habitat protection.

PSRC: The MPO hasn't adopted an official development policies, but the region is subject to the state's growth management law.

SACOG: The Blueprint Plan consists of land use and transportation strategies. Thus, development policies are very much part of the official plan and the modeling effort in Sacramento.

WACOG: COG has not adopted any official policies, but they are adopting a vision and are using scenarios to examine aspects of different development scenarios (this is the Regional Mobility Study).

Your Current Model

9. Which, if any, of the following products do you use to generate land use forecasts (e.g., DRAM/EMPAL, METROPILUS, MEPLAN, MetroScope, PECAS, TRANUS, UrbanSim, other (please identify)? In answering the following questions, please clearly indicate if an answer relates to one of these products.

BMC: Have used DRAM/EMPAL and MEPLAN, now using PECAS.

DRCOG: A "home grown" DRAM/EPAL model, but going to UrbanSim

Technical Follow-up: How long have you been converting to UrbanSim, and when do you think you will be using it to produce forecasts that will be used in a plan update and adoption? **Answer**: John, we've been in slow mode on it for a couple years, as we've been so busy on the travel side, and have been waiting to see how things turn out with the Seattle project. I think it will be at least two to three years before we are using it for regular operations. (The answers to questions 11-15 below are related to the homegrown model.)

H-GAC: UrbanSim

Technical Follow-up: You mentioned that you are still calibrating the UrbanSim model. How long have you been working at the calibration? What have been the challenges in this effort? Have you nevertheless used it for official forecasts? If not, when do you expect to start using it for official forecasts? **Answer**: The first UrbanSim-based forecast was produced in 2003 and was used in the RTP, so it was "official". The second UrbanSim-based forecast was produced in 2005, and is currently being used in RTP development. UrbanSim is evolving, and the 2005 forecast uses a newer version of UrbanSim, with new (different) parameters (and coefficients).

Metro: MetroScope

PSRC: UrbanSim

Updated answer: The agency currently uses DRAM/EMPAL for land use forecasting. UrbanSim is in development, and will eventually succeed DRAM/EMPAL. (The answers to questions 11-15 below relate to UrbanSim.)

SACOG: They use PLACES and PECAS, but have looked at MEPLAN.

Technical Follow-up: The notes of the first interview indicate that you will use PECAS and PLACES together. Apparently, PLACES will provide scenario input to PECAS, PECAS will then provide

forecasts associated with those scenarios, and PLACES will then evaluate the quality of life impacts of the PECAS forecasts. Is this correct? **GG Answer:** PLACE3S will be used as the platform of planning and negotiations with and among the cities and counties. PECAS will be used in that process as an economic evaluator of those plans, to provide a region-wide analysis of market forces and government policies that would enable the 'vision'. The process could also be used with PECAS run first to provide an economic forecast then the final year results input to PLACE3S to run the range of indicators. The final regional growth projections will use both tools as inputs and analysis mechanisms to help produce an agreement among all parties on the most reasonable future for the region. In short, growth projections are always going to be a political process. What we are attempting to do is bring the best analysis to that process.

WACOG: They do not use any land use model.

10. Please describe, in general terms, the technical process for producing land use forecasts at the regional (control values), subarea, and traffic analysis zone levels (If a flowchart is available, please send).

See Section 2.2

11. What control values are required as inputs? What is the source for your control values? Does your model use control values at the sub-region or sector levels? If so, how many sub-regions or sectors?

BMC: They do not use regional control values. This was tried, and it produced a "lot of fights" over the numbers. The regional value is simply the sum of the individual community members' expected growth, in addition to consistency determination with the neighboring WASHCOG. A land use group meets every two months to discuss the latest issues. The input data for population and households does come from local governments. However, for employment numbers, BMC relies on state and BEA data.

Technical Follow-up - At what level of geography does PECAS receive control information on population, households and employment?

DRCOG: An economics consultant provides the regional control value. The panel mentioned previously then discusses the value (usually taking 3 months) and changes are made where appropriate. This happens every 3 to 4 years.

H-GAC: An econometric model is used to develop control values. Developing forecasts for sub-areas is often challenging. For example, determining the amount of developable land is difficult. Characterizing land use is done via the county appraisal files.

Technical Follow-up: Is it correct that the UrbanSim forecasts of employment, population and households are constrained at the county level? (get aggregation level correct) Do these control values all come directly from the econometric model, or is there an additional process by which they are disaggregated to the county level? (what process?) **Answer**: Yes, that's correct. For 2003 forecast, we did use an "econometric" model (REMI). For 2005 forecast, we switched to a simpler demographic model, with a demographic-driven employment forecast. The development of county control totals for population, households, and employment is a multi-step process. The major steps are as follows (details are available in a separate document supplied by H-GAC, entitled "2035 H-GAC Regional Growth Forecast--Control Totals Methodology.doc"):

1. Forecast CMSA population for 2005-2035.
2. Distribute CMSA population forecast to 8 counties.
3. Distribute county total population to demographic (age- and race-specific) groups.
4. Estimate county household population and number of households.
5. Estimate CMSA wage and salary (W&S) employment.
6. Distribute CMSA W&S employment to 8 counties.
7. Distribute county W&S employment to 7 sectors.

Metro: Six county level control totals are used for households by HIAK class and employment by 15 NAICS. These are produced from a regional economic forecast model. They do not use control values at a sub-regional level.

Technical Follow-up: Why do you use the economic forecasting model to generate county-level inputs, rather than generating regional values and having MetroScope distribute them? In what ways does this improve or hurt the quality of the final forecasts? Why don't you use the economic model to generate forecasts at a more disaggregate level? **SC Answer** – Control totals are for a 6 county sum; they are not individual counties.

Technical Follow-up: What are the HIAK classes and the NAICS classes that are used? **SC Answer** – HIAK is for household size (5 categories with 5+ topcode), income (8 categories with 100K + topcode), age (5 categories with 65+ topcode), school age children

present(yes or no). As to NAICS we actually estimate over 30 categories as control totals at the regional level. Depending on use we then aggregate these to anywhere from11 to 15 categories to use in the land use and transportation models. Our 11 category system includes office, durable manuf., computers/electronics, nondurable manuf., wholesale/transport, retail/services, FIRE, health/social assist., general government, k-12 education.

PSRC: The level of aggregation is at a 5 ½ acre grid cell, but can be aggregated to different reporting scales. Control values come from an econometric model used by a contractor. This model is a top-down model, which uses county-level numbers as a way point in the analysis, but not as a control values.

Technical Follow-up: What is the level of aggregation of the values that serve as control values within UrbanSim itself? Are the county-level numbers "way point" inputs in UrbanSim? What do you mean by a way point?

Answer: The base year (currently 2000) for UrbanSim actually starts with the parcel-level data, including the assessors' land use and building files, point-level job data, and the Census estimates of households by block group. These data are "gridded" into the 5.5-acre cells that the model actually operates at. Regional control totals are provided, for each year of the simulation, for:

a. Jobs by sector
b. Population
c. Households

Because of the break in time-series data when the switch from SIC to NAICS employment coding occurred, PSRC had to replace its regional forecasting model, STEP. Through a consultant contract, a new regional model was developed, which now produces county-level forecasts (the previous model only produced forecasts at the regional level, which were then allocated to zones using DRAM/EMPAL, then aggregated back up to county totals.) However, staff still recognizes the impacts local land use plans, major developments, transportation accessibilities, etc could have on the overall growth by county. So the regional-to-zone-to-county method is still being used, but as a quality check, we can refer to the county-level results of the regional model.

Technical Summary of Answer: UrbanSim uses, as control values, exogenous regional forecasts of jobs by sector, population and households. Exogenous forecasts of these variables by county are available to compare to the UrbanSim output. PSRC staff prefers NOT to control UrbanSim at the county level, because of the possibility of county level changes that UrbanSim might pick up that the exogenous forecasting procedure would not pick up.

SACOG: Control values are required for population and employment. As noted, they come from both the Department of Finance and an independent consultant study. SACOG does not believe the DOF numbers, because at the state level, they really are as much the result of a negotiating process as they are a modeling effort.

Technical Follow-up: Does PECAS use any control inputs that are less aggregate than regional totals? **GG Answer:** The control inputs on population, housing, and employment (by sectors) will be regional totals. Dr. Meyers' interpretation of our comments are slightly off the mark. The DOF process is mostly quantitative, but there is a negotiation of final numbers with the regions. It is probably 80-90% quantitative.

Other control values: development policies are by jurisdiction, the developers' costs of residential and commercial buildings have some spatial variation.

WACOG: Employment by sector for the region….not divided into sub-regions.

12. What are the major data inputs into your model for forecasting? What additional inputs are/were required for model development? How satisfied are you that these data inputs are reliable and valid?

BMC: Input includes things like income, non-institutional group quartiles, number of workers, auto ownership, a household matrix etc, most of which serves as input into the travel demand model. There is general consensus on the employment forecasts, although at least on environmental group argues they are too high.

DRCOG: Local governments provide estimates of households and employment by TAZ. DRCOG treats these as a "capacity threshold" for the TAZ's, that is, the levels of population and employment that might happen in each zone.

H-GAC: Inputs include such things as existing land uses and the developability/ redevelopability of land. Highway skims are produced from the demand model. New projects are added to the coded network at five-year increments. Currently, they are not recycling congestion values into the land use model. They are working on incorporating transit and toll costs into the skims, but have not done so yet. Socio-economic characteristics come from the population synthesizer.

Metro: *Data include: the stock of land resources both vacant and refill by zone class, the amount of land to be added to the UGB, the transportation supply schedule and whatever zone changes or urban renewal areas that are to be assumed to be added in the future. Everything else is endogenous or part of the year 2000 base of observable initial conditions (i.e., housing and nonresidential real estate stock and transportation system). Housing and location choice and price data for parameter estimation for residential demand equations are additional inputs. Similarly, choice and aggregation patterns for nonresidential demand equations are needed, as are Initial land value and construction cost data for residential and nonresidential supply equations. MetroScope is much more dominated by the logic of its structural equations and equilibrium assumptions than it is by parameter estimates and the accuracy of initial condition assumptions. Besides the usual statistical fitting exercises we perform extensive sensitivity testing particularly to establish indifference curves between commuter travel time, real estate price and neighborhood quality. Parameters are further adjusted to ensure compliance with fairly well established values for the value of time.*

PSRC: *Very similar to other MPO efforts, households, population, employment, developable land, transportation system performance, etc.*

SACOG: *Inputs include households, population, employment, information from local plan, an environmental layer on their GIS system, and assessor's data (although they did not think the assessors data was very good). They also have a "redevelopability" dataset that is done parcel by parcel, which primarily relates to age of structure on the parcel.*

13. What are the major data sources for these inputs? What is your estimate of the amount of time it has taken (or will take) to obtain the data inputs to your land use model? What percentage of the overall land use modeling effort for one transportation planning cycle do you think this represents?

BMC: *Sources of land use input include property appraisal, building permit, and zoning databases. Their databases represent millions of records and are used to feed PECAS.*

Technical Follow-up: What specific inputs to the PECAS model (as opposed to the travel model) are required **for forecasting**? What additional inputs were required **for model development and calibration**? (Try to get a detailed list)

DRCOG: Census data are used for household information. ES202 data are used for employment data, and DRCOG is able to get this data at a very disaggregate level. They get employment data at specific (x,y) coordinates. Between Census dates, DRCOG "grows" the data by linking it to the local energy company's database on power hook-ups. They have point coverage for new hook-ups, which they give to DRCOG for its estimation of growth in households and businesses. In addition, DRCOG seeks contributions from companies and local agencies to fund aerial photography every 2 years. Those who contribute get the photos. As noted, one of the key challenges in the data is the level of building vacancy. Employment data need to be massaged, which is a continuous process. Between 1 and 2 staff members do this at any one time (e.g., determining where corporate employees really are… not all at the corporate headquarters).

Technical Follow-up: What specific inputs to your model (as opposed to the travel model) are required **for forecasting in addition to the TAZ capacities provided by local governments**? **Answer**: We calculate "utility functions" for each zone, which feeds how much of the reported capacity will be built. The following table shows them:

TABLE 1 DRCOG Variable Inputs

Variable	Description	Data Inputs
Xath	Access to x households within 20 minutes by highway	Household points, employment points, CTPP data, Transcad model runs
XathT	Access to x households within 20 minutes by transit	
Xatj	Access to x jobs within 20 minutes by highway	
Xatj T	Access to x jobs within 20 minutes by transit	
Xcenter	Share of an area with a recognized regional and urban centers and corridors	TAZ layer, local urban form plans
Xemp	Current total employment	DLE ES202 data from 1996, 2000, and 2002
Xempg	Rate of employment growth from the previous period	
Xenv	Areas with environmental constraints affecting development	ugb, water, natural hazards, slopes
Xhhs	Current total households	DRCOG HH count estimates, 2001, 2003, 2004
Xhhsg	Rate of household growth from the previous period	
Xinc	Distribution of household income within the area (share of higher income)	2000 US Census Median HH inc
Xitchg	Share of land impacted within 1/2 mile of a highway interchange	1/2 to 2 miles from interchange
Xjhb	Jobs-Household balance in the immediate (5 mile) area	DRCOG estimates, Commute Dist
Xmix	Differences from the regional mix of housing values and the regional share of jobs to households	% hhold inc by type, emp points
Xmph	Average value of (own) houses within an area	2000 US Census median HH price
Xmphg	Change in value of housing	
Xosp	Access to open space areas and where open space preservation is desired	parks and open space GIS layer
Xped	Areas that are pedestrian friendly, using road intersections as a proxy	local road network
Xredev	Number of acres of additional land that will likely be redeveloped due to the age of the housing stock	Med hh unit age, TAZ acreage
Xrural%	Share of an area that is rural (and semi-urban) in land pattern	
Xsca	Areas that are influenced by proximity or access to social/cultural amenities	SCA Facility addresses, road network
Xsta	Share of an areas with 1/2 mile of rail and BRT station	1/3 mi to mass transit station
Xugb	Share of an area within the urban growth boundary	% developable land in the UGB
Xuts	Share of an area that is or will be served by a sewer provider	state water plans, primary water providers, treatment capacity
Xutw	Share of an area that is or will be served by a water provider	
Xvac	Number of vacant, development acres of land (for the specific purpose identified)	

H-GAC: H-GAC never stops collecting and massaging land use data. The land use data effort for the transportation plan update represents about 70% of the total land use effort, and forecasting applications represent about 30% of the time.

Technical Follow-up: Are the skims used directly by UrbanSim (as opposed to some composite measure such as a logsum)? Which skim variables are used by UrbanSim? How are you trying to incorporate transit and toll costs into the skims, and how far along in the process are you? **Answer**: UrbanSim uses travel time skims directly, as well as mode choice logsums (as a cost proxy) and measures of physical proximity to transportation facilities. Transit and toll costs would come via the logsums, to the extent that these variables are included in the mode choice model. H-GAC has not tested UrbanSim sensitivity to transit and toll costs.

Technical Follow-up: What does it mean that you are not recycling congestion values into the land use model? (i.e. does it mean that UrbanSim uses skims that don't change when you rerun the travel demand model?) **Answer:** Land use forecasts and travel demand forecasts are generated independently by separate departments. When the land use forecast is produced, it used transport skims and accessibility information that depend on the forecast year, but as generated in the most recent run of the long range travel demand forecast. Likewise, when a long range travel demand forecast is produced, it uses land use inputs that depend on forecast year, but as generated in the most recent run of the long range land use forecast.

Technical Follow-up: Where does the population synthesizer fit in the land use model? (For example, does UrbanSim create and use a base year synthetic population as its input for future year land use forecasts?) **Answer:** UrbanSim creates a base year synthetic population. It then proceeds to generate its forecasts without creating or re-synthesizing a forecast year synthetic population.

Technical Follow-up: What specific inputs to the UrbanSim model (as opposed to the travel model) are required **for forecasting**? What additional inputs were required **for model development and calibration**? (Try to get a detailed list) **Answer:** UrbanSim requires a base year synthetic population and transport accessibility information as described above, as well as the following base year information for each grid cell: employment by sector, housing units and non-residential square footage, land value, improvement value, and land use category.

Metro: *Census PUMA's, Survey of Consumer Expenditures, Metro Regional Land Information System (RLIS). It takes usually two to six months including parameter estimation and sensitivity testing. This represents about 15 – 20% of the land use modeling effort. Local agencies review input data on capacity and update it with latest plan changes. They also review assumptions and redevelopment and infill potential.*

Technical Follow-up: What is the nature of the transportation supply schedule, and how is it produced? Does it capture the effect of tolls, transit accessibility, and other transport policy and accessibility effects? **SC Answer** - 2029 taz system with links, nodes, etc. Either emme2 or VISUM (PTV America). All costs, travel times, transit, other modes, etc. are counted as we use the mode weighted log sums as our impedance measure. (we actually reconvert this measure back into a travel time for a variety of communication and evaluation reasons).

Technical Follow-up: To what extent is the model built around the presence of the UGB? Would it make good forecasts in the absence of a UGB, in a region with a more sprawling development pattern such as Atlanta? How much person time would it take to implement it in the Atlanta context, assuming that the needed data is available? **SC Answer** – There is nothing in the model that can "detect" the UGB. What the model uses is the supply of available land that is on the market at that time period and its zoning designation and capacity. From a land supply perspective two issues are relevant – how much land is being brought to market (even in the Metro region 3 – 8 times more land is usually available than growth will consume at any given time period) and secondly what it's zoning? Land outside the UGB gets a very low density rural designation or if its EFU/FF (ag-forestry) no capacity at all. Most important is that zoning is exogenous in MetroScope. Some models may incorporate endogenous zoning (highest and best algorithm of some sort). Atlanta may want that feature.

As to time, since the Atlanta Region has very capable staff, I estimate 2 – 3 months (6 – 9 months FTE) for a baseline calibration using default parameters. In other words calibrate to zonal control totals by changing "location prices". They would probably take another 2 – 3 months doing a 2030 – 35 base run and critiquing output. ("goodness of fit" measures are really useless here – what you need to do is a forecast to test model properties and substantial amounts of sensitivity testing – also start in year 2000 and compare year 2005 with estimates of some actual data.)

PSRC: *Input data included:*

-Assessor's data for parcels and buildings including square feet and attribute data.

-Long range comprehensive plan information if used as input as well.

-A GIS overlay for environmental constraints indicates areas that need to be avoided.

-Demographic tables including jobs and households (which come from the synthesis module.

It takes about 1½ years to clean up the input data (which was a surprise to PSRC). They worked with a users group and local planners in putting this data together.

The biggest holes include:

--Jobs/ft^2 which is needed to synthesize households.

--Assessor's data lag current market conditions and use different tracking codes

--Insufficient temporal record of land value trends

Because URBANSIM is relatively new, there has been some redevelopment activity. PSRC had a 2-year contract with the University of Washington ((paying for 2 FTE's) for data collecting and cleaning. This represented 2 to 3 staff members.

Technical Follow-up: How are the grid-cell land use attributes determined for forecast years? To what extent does UrbanSim generate these, and to what extent are they input as scenario information? For the latter, how are the scenarios generated? **Answer:** Pasted below is the current Grid Cells table structure for the PSRC UrbanSim model. The "built" variables, such as SQFT, value, and units are the results of the UrbanSim Developer Model suite, which annually determines how many new housing units and job-containing SQFT will be added to the region, then sites them on specific grid cells. These are shown in boldface in the table. Values that are specific to individual scenarios include location relative to roads, percent in undevelopable categories of land (i.e. wetlands), in/out of the Urban Growth Boundary, and the PlanType ID, which represents the Comprehensive Plan designation. These, along with constants that do not change with time (eg, Grid ID), are shown in regular typeface. Scenarios we have tested so far have been user-defined tests of model sensitivity.

GRID_ID
COMMERCIAL_SQFT
GOVERNMENTAL_SQFT
INDUSTRIAL_SQFT
COMMERCIAL_IMPROVEMENT_VALUE
INDUSTRIAL_IMPROVEMENT_VALUE

GOVERNMENTAL_IMPROVEMENT_VALUE
NONRESIDENTIAL_LAND_VALUE
RESIDENTIAL_LAND_VALUE
RESIDENTIAL_IMPROVEMENT_VALUE
RESIDENTIAL_UNITS
YEAR_BUILT
FRACTION_RESIDENTIAL_LAND
PERCENT_UNDEVELOPABLE
TOTAL_NONRES_SQFT
TOTAL_UNDEVELOPABLE_SQFT
DEVELOPMENT_TYPE_ID
DISTANCE_TO_ARTERIAL
DISTANCE_TO_HIGHWAY
RELATIVE_X
RELATIVE_Y
PLAN_TYPE_ID
PERCENT_WATER
PERCENT_WETLAND
PERCENT_STREAM_BUFFER
PERCENT_FLOODPLAIN
PERCENT_SLOPE
PERCENT_OPEN_SPACE
PERCENT_PUBLIC_SPACE
PERCENT_ROADS
IS_OUTSIDE_URBAN_GROWTH_BOUNDARY
IS_INSIDE_NATIONAL_FOREST
IS_INSIDE_TRIBAL_LAND
IS_INSIDE_MILITARY_BASE
ZONE_ID
CITY_ID
COUNTY_ID
PERCENT_AGR_KING
ACRES
PERCENT_AGRICULTURAL_PROTECTED_LANDS
PERCENT_FOREST
PERCENT_MINING
PERCENT_ROW
COMMERCIAL_SQFT_PER_JOB
INDUSTRIAL_SQFT_PER_JOB
UNDEVELOPABLE
LARGE_AREA_ID

Technical Follow-up: What inputs does the synthesis module require, and at what level of aggregation? Does the synthesis module require this for the base year only, or also for forecast years? **Answer:** The synthesis model is still under investigation. Currently it needs Census tables and PUMS data, for the base year.

Technical Follow-up: Where does the population synthesizer fit in the land use model? For example, does UrbanSim create and use a base year synthetic population as its input for its land use forecasts, and does it evolve this population or re-synthesize it in subsequent years? On what characteristics of its synthetic households does UrbanSim depend? Have they been tested for validity in the base year? In a subsequent forecast year population? **Answer:** The population synthesizer has been the subject of a lot of discussion

about various ways to improve the process. Currently the PSRC version creates a synthesized database of individual households for the base year, controlling to a number of variables from the 2000 Census. For each of the 1.2 million records / households, the synthesizer fills the following fields:

HOUSEHOLD_ID
GRID_ID
PERSONS
WORKERS
AGE_OF_HEAD
INCOME
CHILDREN
RACE_ID
CARS

Currently the population does not age or evolve; each year UrbanSim adds a number of households to the mix, randomly selecting attributes for each household according to the 2000 data, making sure that the selections line up with whatever control totals put in. I would have to review the most current model estimation report to see what variables are factors in what sub-models in UrbanSim currently (for example, I'm expecting some factor of Income to value in the grid cell to be significant in the Household Location models).

Technical Follow-up: What specific inputs to the UrbanSim model (as opposed to the travel model) are required **for forecasting**? What additional inputs were required **for model development and calibration**? (Tried to get a detailed list) **Answer:** UrbanSim requires control totals for each of the employment sectors and households. A land use code, comp plan or zoning, is also needed, along with an interpretation of what minimum and maximum development can occur on that grid cell with that code. This can be set up to vary by city, county, location in/out of the UGA, etc. Model calibration required assembling trend data in parcels and employment. For jobs, the best available dataset was 1995, with a base year of 2000. For parcels, a 1990 land use coverage was set up by "rolling back" parcels using the year built entry in the assessor's data, to create vacant parcels. Trend data was also needed corresponding to the parcels database, back to 1990, that related the size and frequency of development events to the land use database.

We haven't assembled an updated list of all inputs needed for model development and calibration that is scheduled to be done soon as we prepare to do an updated 2006 UrbanSim Base Year database. However, a significant amount of documentation on the initial PSRC database assembly work can be accessed on the UrbanSim web site, at http://www.urbansim.org/projects/psrc/. While some of it is out-of-date, it provides a good summary of the key steps and data needed.

SACOG: Same as #12.

Technical Follow-up: Apparently, some of the future scenario parcel attributes are developed in PLACES. How else are any PECAS input attributes generated, and at what level of aggregation? (no answer)

14. What are the major outputs of your land use forecasts, and at what level of geographic detail? At what level of socio-demographic detail are the forecasts of households and population? At what level of industry sector and job classification detail are the employment forecasts?

BMC: Forecasts are distributed to the TAZ level. PECAS distinguishes between blue and white collar employment, with all major employment sectors represented – retail, non-retail, office, industrial, etc. This data is much more detailed for PECAS than for the travel demand model.

Technical Follow-up: Are the forecasts distributed to TAZ level directly by PECAS, or in a post-processor? (If post-processor, learn about it). Have you tested the validity of the forecasts at the TAZ level? What have you found, or what do you think you would find? Can we get a list of the sector/occupation type categories of the PECAS employment forecasts? What are the socio-demographic categories of the population and household forecasts?

DRCOG: Outputs are regional and households and employment forecasts are disaggregated to the TAZ level. Households are stratified by low, medium, and high income. Employment is split into 5 categories- production, retail, service, contract, and self employed.

Technical Follow-up: How are the results disaggregated to the TAZ level (ARC is interested in technical details of this procedure)? **Answer**: The results are generated at the TAZ level: no disaggregation is required. A development capacity is solicited from local gov't for each TAZ, and the utility fn is created for each TAZ. A build rate is created from the utility fn, and the total forecasted development is a function of the build rate and the capacity.

H-GAC: H-GAC uses a 1,000 foot grid for its forecasts, which are then aggregated to the TAZ level. This scale of application allows them to analyze at a very fine level of detail. Employment forecasts are done by industry type, then reclassified into occupational categories – retail, office, industrial, educational, and other government/institutional uses. This classification was important because of the heavy presence of mining and manufacturing in Houston.

Technical Follow-up: Have you run a future year run and produced forecasts with 1000 foot grid cells? Do you produce at sub-area level and then disaggregate to grid cells? If so, how? **Answer**: The 2003 and 2005 UrbanSim forecasts were for 1000x1000 grid cells. They do not need to disaggregate; rather, they aggregate to TAZ.

Technical Follow-up: What are the industry types of the employment forecasts? By what mechanism are they reclassified into occupational categories? Is that done within UrbanSim or as a post-processor? Was it developed specifically for you? Please explain further what is meant by saying that mining and manufacturing make this classification important. **Answer:** Their version of UrbanSim is set up to generate grid-cell forecasts for seven standard industrial classifications. H-GAC has created their own post-processor to transform them into the eight employment categories used by the travel demand model, including the "office" category that cuts across industry classifications. It was important to them to use industrial classifications in their land use model, because they want to distinguish the oil and gas sector.

UrbanSim allows the user to choose what categories it uses for its forecasts. It would be possible to set up the categories so they are compatible with the travel demand model. H-GAC will probably move this direction in the future.

Technical Follow-up: **W**hat are the socio-demographic categories of the population and household forecasts? **Answer:** UrbanSim uses ethnicity, age of head, income and various other demographic variables. However, the income distribution (and perhaps other demographics) stays the same throughout the forecast. The only UrbanSim output that is provided for use by the travel demand model and otherwise is at the TAZ level of geography, and includes only: number of households, number of persons and employment in each sector. The travel models make their own assumptions about demographic distribution within TAZ.

Metro: *According to Metro, land use model output is very prolific; MetroScope is no exception. On the residential side, they provide data for 4 housing/tenure types by 8 value/size categories for 425 R-zones populated by 400 classes of age, household size, income and school age children present. From the supply side, they can link that up with whether the development occurred on vacant land, refill land, land added to the UGB or urban renewal land. On the nonresidential side, they output 6 real estate types inhabited by 15 NAICS employment types by 72 E-zones. Likewise, from the supply side they can link the development to vacant land, refill land, land added to the UGB or urban renewal land. Prices by real*

estate type by zone are available for land and total real estate by 5 year time period.

Technical Follow-up: What are the socio-demographic characteristics of the households that are considered valid for travel demand modeling? Have these been tested for validity in a base year population? In a forecast year population? **SC Answer**- We pass the detailed demographic data (400 classes in 4 dwelling unit types in 425 zones) to transportation where they "post process" it to provide the socio-economic data they need for whatever transportation model they happen to be running at the time. Transportation's current set of about 5 – 6 models are estimated on the 96 survey data and calibrated to whatever traffic flow data are most current. Again MetroScope produces far more output than we can actually measure, so I am unsure what forecast year population means in the transport model sense.

PSRC: *The major outputs are households, population and jobs by sector. The jobs by sector are at a much higher level of disaggregation than was used by DRAM/EMPAL (5 sectors vs. 15). The 15 are consistent with the travel demand categories. The cells are aggregated to the TAZ and county levels. PSRC does an extensive QA/QC on these outputs.*

Technical Follow-up: What is the specific list of 15 sectors in the employment forecasts? Answer: The list of 18 sectors is below; we may have mistakenly said 15 when talking to Mike Meyers. Note though the 5 GovEd sectors are not located through a Location Choice model, rather, the totals are adjusted through a Scaling model.

sector_id	Major Sector	Name
1	ResCon	Resource
2	ResCon	Construction
3	Manuf	Manufacturing – Aviation
4	Manuf	Manufacturing – Other
5	WTCU	Transportation
6	WTCU	Communications and Utilities
7	WTCU	Wholesale Trade
8	Retail	Eating and Drinking Places
9	Retail	Other Retail Trade
10	FIRES	Finance, Insurance, and Real Estate
11	FIRES	Producer Services
12	FIRES	Consumer Services
13	FIRES	Health Services
14	GovEd	Federal Government, Civilian
15	GovEd	Federal Government, Military
16	GovEd	Education, K-12
17	GovEd	Education, Higher
18	GovEd	State, Local Government

Technical Follow-up: What are the sociodemographic characteristics of the households that are considered valid for travel demand modeling? Have these been tested for validity in a base year population? In a forecast year population? **Answer:** The travel demand model uses a TAZ-level cross-classification of households by size, income and number of workers. For school trips it uses a classification of HH by number of school age children. For college trips it uses a classification of HH by number of college age persons in HH.

The implementation of UrbanSim has not yet reached the stage of validating these characteristics of the base year population that the household synthesizer provides as input to UrbanSim, or the forecast population output by UrbanSim.

SACOG: *Outputs include land use projections by land use type, and a population synthesizer is used as part of the travel demand model. The synthesizer provides number of persons, number of workers, income levels, number of children, etc..*

Technical Follow-up: What are the land use types of the PECAS forecasts? At what level of geographic detail are the forecasts produced? **GG Answer**: I am attaching a paper, "Built Form Synthesis Paper,009.doc, which is (I think) the final version of a TRB paper that John and Doug wrote. It has land use types and other details on the work to date. The developer model produces parcel level building inventory that the residential and commercial allocation modules use in location choice at a zonal level. **Answer (From Sacramento PECAS paper)**: In PECAS, land is categorized two ways, by the type of floor space developed on it, and by the type of activity which occurs in that floor space. Floorspace development occurs in the developer model, which operates in Sacramento at the parcel level, so development category is a parcel attribute output of PECAS. The development categories are:

Luxury Single Family Dwelling
Standard Single Family Dwelling
Owned Multi Family
Rented Multi Family
Ag and Mining Space
Industrial space
Office space
Retail space
Medical space
Primary school space
Colleges and education space
Government office space

Activities are modeled in the aggregate spatial IO model component of PECAS, which associates each unit of activity with a zone in which it occurs. In Sacramento, PECAS uses a 650 zone aggregation of the transportation analysis zones (TAZ). So, the

amount of residential and nonresidential activity is a zonal attribute output of PECAS. The nonresidential activity categories are:

AGRICULTURE (plus mining) production
AGRICULTURE (plus mining) office support
CONSTRUCTION
MANUFACTURING production
MANUFACTURING office support
TRANSPORTATION SERVICES
COMMUNICATIONS AND UTILITIES production
COMMUNICATIONS AND UTILITIES office support
WHOLESALE TRADE warehousing and transportation
WHOLESALE TRADE sales and management
RETAIL TRADE
RESTAURANTS
FINANCE INSURANCE LEGAL
REAL ESTATE
HOTELS
BUSINESS SERVICES production
BUSINESS SERVICES office support
AUTOMOTIVE SERVICES
AMUSEMENT SERVICES
HEALTH SERVICES
PRIMARY EDUCATION
OTHER EDUCATION
PERSONAL SERVICES
MEMBERSHIP & NON-PROFIT ORGS
PROFESSIONAL SERVICES
GOVERNMENT NONUTILITY ENTERPRISES
MILITARY
FEDERAL GOVERNMENT
STATE AND LOCAL GOVT

The residential activity categories are:

HH Income lt 10
10 to 15
15 to 20
20 to 25
25 to 30
30 to 35
35 to 40
40 to 45
45 to 50
50 to 60
60 to 75
75 to 100
100 to 125
125 to 150
150 to 200
200 or more

Technical Follow-up: What PECAS output attributes do you intend to use as controls in the population synthesizer, and at what level of geographic aggregation? Have you tested their validity, or do you intend to, and what are you current views about their validity? How are the PECAS outputs disaggregated to parcel level for feedback to PLACES? **GG Answer**: As far as other issues on integration of PECAS and SACSIM I would need more time (and probably some

of your time, Mark's, John Abraham's and Doug Hunt's) to work them out.

15. How does the model link to the transportation model used by your agency for transportation planning, either in the development of the regional transportation plan or for other planning efforts, such as corridor or community plans? How do the land use forecasts depend on outputs of the transportation model and vice versa? What is the role of transit accessibility in producing subarea or zonal land use forecasts? Can your transportation model include toll pricing? If so, have tolls been incorporated into your transportation model when land use forecasts have been made, and do they affect the land use forecasts?

BMC: *The travel demand model is run on yearly iterations when forecasting future demand. PECAS is then used to update the land use every five years. The forecast horizon is 2030. Tolls can be represented in the travel demand model which then acts as input into PECAS. However, they have not done this yet.*

Technical Follow-up: What input from the transport model is used by PECAS when it updates the land use every five years? And how (i.e., where within the PECAS model) does it use that input? Does the input come from the same transport model that you use for travel demand forecasts?

Technical Follow-up: Is transport accessibility an input that helps explain land use model outputs? If so, does the accessibility information come from the transport model? If not, where does it come from? Does it include transit accessibility? How sensitive is the land use model to transit accessibility?

Technical Follow-up: Is the transport model now capable of toll scenarios? If so, and the forecast was for a toll scenario, would the PECAS model input from the transport model include the toll effects? If not, why?

H-GAC: **Technical Follow-up:** See supplemental question and answers for question 13.

DRCOG: *The model generates a 2030 forecast and then DRCOG linearly interpolates for the intermediate years. This is not a sophisticated approach, and they would like to develop one that is more based on a build up of development over intermediate timeframes (e.g., every 5 or 10 years).*

Transit accessibility is incorporated into the zonal utility functions (HH's within 20 minutes by transit or HH's within ½ miles of transit station). The allocation to such zones receives a "utility bump" when such transit service is available. DRCOG does not have a generalized cost function in their model and thus cannot model tolls as part of the land use forecasting process.

Metro: *They use mode weighted log sums from the travel model usually lagged 5 years (contemporaneously involves 1 more iteration, which are usually done in the final forecast period). They are also just completing with PTV America a fully integrated simplified transportation model directly within MetroScope that allows a full 30 to 35 year run at one time on one computer. All MetroScope runs use transportation level of service data as part of the information the model uses to determine the allocation of real estate. The transportation model uses household data by TAZ by class and employment data by TAZ by class to determine traffic generation and distribution. They use mode weighted log sums. Travel cost is part of mode share and assignment arguments, but they do not affect land use forecasts.*

Technical Follow-up: How are the mode-weighted logsums calculated, and why doesn't travel cost affect land use forecasts? Do you have any plans to enhance the model to make land use forecasts sensitive to tolls and other costs or to time of day variations in transport level of service? **SC answer** – I think maybe my original answers got reinterpreted too many times. Travel cost of course is part of the mode weighted log sums which we use and then convert back to a travel time equivalent (i.e. parking charge downtown gives you another 6 – 9 minutes travel time depending on your transit mode split). In other words, Metroscope on the land use side simply takes what the transport model sends it. If the transport model in use, makes detailed calculation of various transport costs, etc. then it gets reflected in Metroscope.

Technical Follow-up: Dick Walker has indicated that Metro is planning to implement and use an activity-based model system for travel demand forecasting. Do you intend to integrate that into MetroScope? What challenges would be faced in trying to do that? **SC answer** – As long as we have a scheme for converting the resultant sets of log sums into an appropriately weighted zone to zone average, we have no problems. Without sounding too pedantic, keep in mind that land use models appropriately specified incorporate transportation factor inputs into very complex household utility and producer production functions with numerous substitutes and complements. The result is that changes that appear material at

the transportation model level may not be detectable at the land use model side.

PSRC: DRAM/EMPAL iterates 5 times; URBANSIM iterates every 5 years. The travel demand model does include tolls, but not linked directly to URBANSIM. Tolls are found in the impedance estimate.

Technical Follow-up: Which transportation performance variables are used by UrbanSim? Are skims used directly by UrbanSim, as opposed to some composite measure such as a logsum? Will you try to incorporate transit and toll costs into the skims, and if so how do you intend to do it? When UrbanSim reiterates after 5 years, have the transportation performance variables changed? **Answer:** Paul Waddell has experimented with mode choice logsums and highway generalized travel times. He tried weighting the highway generalized travel times by trip tables, but these didn't vary in the future weighted skims. Larry Blain thinks Paul reverted to highway generalized travel times. At best transit is represented as part of a logsum. Tolls are included in the generalized times, used in distribution and mode choice, and output by assignment. Parking price enters only mode choice. So, if the mode choice logsums are used, then transit, tolls and parking prices are included in the transport performance measure fed back to UrbanSim from the travel demand model. If highway generalized times are used, then transit and parking costs are NOT fed back. UrbanSim is set up to allow rapid re-estimation of the models. Therefore, it is possible to quickly change which type of transport variable is fed back to UrbanSim.

UrbanSim runs for every year. It uses updated highway generalized costs or logsums on every fifth year, and uses a new transportation network and costs every tenth year. This schedule is not fixed by UrbanSim, but rather was chosen by PSRC. UrbanSim could just as easily use transport model feedback every year. PSRC chose the 5-year schedule because it takes 18 hours to run the travel demand model.

SACOG: They will be looking at the impact of parking pricing, but have not yet done so. They have not looked at tolling, and don't expect to because they do not think there are many tolling opportunities in the Sacramento area. They are also expecting to do a scenario on the price of oil.

Technical Follow-up: Do you intend to integrate PECAS with the new activity/tour based travel demand model, or with your current travel demand model, or with some simpler travel demand component within PECAS? **GG Answer**: The first version of

PECAS will be matched with the current trip based model, SACMET. I think that there will be enough variables and unknowns in PECAS, so I would like to have it matched with a travel model that we have a lot of experience with. Eventually I would want to use SACSIM as the travel model.

Technical Follow-up: Will the impact of parking pricing be captured via travel demand model outputs, or some other way? **GG Answer**: Parking costs in SACMET now are estimated as a function of employment density from the PLACE3S data. If we test a policy based parking charge it will be added onto this market based parking cost.

Technical Follow-up: What variables from the travel demand model do you expect to use as input into PECAS? How do you expect them to capture the effect of transit accessibility? What other effects do you expect them to help capture? **GG Answer**: If I remember correctly we are using the logsums from the mode choice models to feed travel impedances into PECAS. But that could be wrong and Hunt and Abraham could have some other indicator that they have developed from the Oregon and Ohio work.

WACOG: There is no feedback into local land use forecasts from the travel demand model results. The land use forecasts are not formally adopted until the transportation plan undergoes a conformity analysis. As described above for the Intercounty Connector, the COG does go back to the jurisdictions and asks if a new major transportation facility will likely change their TAZ forecasts. This has also occurred when new Metro stations were opened.

16. How far in advance of the beginning of the travel demand modeling effort for a transportation plan update do you produce land use forecasts? Are these forecasts officially adopted by your Board before using them for transportation planning purposes?

BMC: The forecasts are updated regularly (every one to two years), so they are readily available when a transportation plan update is underway. The Board does officially adopt the forecasts.

DRCOG: For an annual update effort (every two years) they spend 2 to 3 months prior to the transportation demand modeling developing an updated TAZ forecast. For a major plan update (every 4 years), they spend 6 months updating the forecasts, and they assign substantial staff resources to their effort. They have a good track record of having land use forecasts available prior to beginning the demand modeling effort.

Forecasts are not officially adopted except to the extent that they are part of the officially adopted transportation plan.

H-GAC: Forecasts are done one year prior to the transportation modeling process. The county control values are officially adopted by the Board.

Metro: There is no set standard on this. "Official forecasts" take a long time with the review process and the politics of UGB expansion assumptions, etc. so they generally fall behind the RTP update cycle. The forecasts are not officially adopted.

PSRC: For a normal transportation plan update process, the PSRC Board gets advised of the forecasts. Updates occur every 3 to 4 years. However, every 15 years PSRC does a major visioning process where they try to consider policies that will influence growth. In these cases, the Board often wants to change forecasts to reflect desired outcomes.

SACOG: They have adopted an interesting perspective on when land use forecasts are "finalized." Because of the emphasis on land use as strategies, they develop draft land use forecasts to begin the process, but then do not adopt official forecasts until the transportation plan is adopted because the land use might change. For example, some corridors might be ripe for additional densities given the right transportation investment.

17. To what extent is your land use model used for assessing different land use/development scenarios? If you do conduct scenario analysis, do you change the coded transportation network for each scenario, or simply change population, household and employment spatial allocations artificially to assess likely impacts on existing transportation networks? In your opinion, is your land use model a good tool for conducting such scenario analyses? If your land use model has been used in such a capacity, to what extent did the analysis results influence MPO or local government policy?

BMC: They really haven't done much with scenario analysis, although they did look at different development scenarios with respect to military base closings. Also, in the context of corridor studies, they have examined the implications of TOD. BMC staff have identified some likely scenarios, and they would "love the opportunity" to test them.

DRCOG: Scenarios were very much part of the METROVISION process. DRCOG has used a less intensive scenario approach for minor plan updates. For example, they have looked at "what if?" scenarios for continued sprawl (by adding "capacity" to the outlying zones), increased transit oriented

development, and greater frequency of service (they already have large transit investment committed as part of FASTRACKS and thus don't feel like they need to look at extensive new transit capacity). For METROVISION, they kept the transportation network constant and changed the land use patterns (otherwise, it would be difficult to identify the causes of change). Their hope, however, is to mix and match transportation scenarios and different land use scenarios. DRCOG thinks their model is a "decent" tool for doing scenario analysis. However, they are looking at UrbanSim for providing a better analysis capability.

H-GAC: Land use modeling is being used as part of the on-going visioning process. Scenarios will be compared to the baseline forecasts. UrbanSim allows H-GAC to show outcomes that look like what the visioning participants had in mind.

Metro: MetroScope is used primarily for scenario analysis to determine the impacts on land use and transportation of a number of policy options for land use regulation, subsidies and transportation investment. Sometimes they change the transportation network; sometimes not depending on what scenario we are looking at. MetroScope was developed with such scenario testing as its principle use. It helped establish guidelines for the amount of growth allocated to the region, versus outside the region, and determined the importance of urban renewal for center revitalization, confirmed assumptions on level of redevelopment and infill, provided the base data for the State required Housing Needs Analysis, and Urban Growth Report necessary for UGB expansion.

PSRC: Scenario analysis will be used by PSRC. Their approach is to pick a transportation network, and then change land use, which is a lot of work. They are developing a database editing program that will allow them to modify networks easily. The demand model is EMME-2. On paper the land use model is a good tool for conducting scenario analysis. The DRAM/EMPAL model was not. The impact of the scenario analysis has been minimal.

SACOG: PECAS will be used for scenario analysis. So far, much of their analysis has not provided land use feedback to travel modeling or for that matter for the feasibility of desired policies on the part of local officials. Will there actually be a demand for the types of development policies espoused by some? PECAS will give an economic evaluation of the likelihood of such development actually occurring. This will then be fed back to PLACES to determine impact on quality of life.

WACOG: COG is now doing scenario analyses with respect to its regional mobility planning. They like scenario planning because is really engages local officials, citizens….in fact, the COG official interviewed thought it is the most popular part of the transportation planning process. Important development issues are brought to the attention of local officials through scenario tests.

18. What is your estimation of the quality of the forecasts produced by your land use model? Do you think that state and local officials place credence in these forecasts? Have you evaluated previous forecasts with currently available census data to assess the quality of the forecasts?

BMC: BMC is trying to make sure the model is transparent as possible, and thus the emphasis on improving local data input. Local officials are interested in the process and the results, especially the planning directors. State and federal agencies have expressed interest in the forecasts, but have not tried to influence the process.

DRCOG: The regional forecasts are very good, with a good track record of coming close to reality. DRCOG did look at the 1960 to 2000 forecast for population, which was 2.3 million….the actual number was 2.4 million.

At the subregional level, they think the forecasts are good, but hard to tell because there has not been much validation. The first light rail transit line analysis underestimated ridership by 15%. However, DRCOG did do better than a consultant who was hired to estimate volume for a new toll road. DRCOG estimated 80,000 jobs in the study area for the forecast year, the consultant 119,000 jobs, and the actual number was 70,000.

H-GAC: It is too soon to tell about the quality of the forecasts. They are still working on model calibration.

Metro: Based on consistency and completeness criteria – excellent. Based on agreement with short term trends – good. Model output is reproducible; time trend and expert panel usually is not; no one knows how certain numbers came to be. In MetroScope, they can go back and see exactly how a specific allocation occurred; so if there is a difference of opinion with a reviewer we can talk about capacity, transportation level of service and competition with the rest of the region; not just whether a number looks high or low. State officials like the

completeness and transparency of the model and local officials have learned that the model treats them fairly. They have compared the 2005 forecast to building permit and employment numbers that are available (they continue to use a base year of 2000 so that we can check the model ex ante in 2005.). There is good agreement in most areas except renter multi-family where the model over predicts in some jurisdictions with heavy multi-family renter zoning.

PSRC: The issue is not quality of forecasts, but the reasonableness of the process in producing forecasts. DRAM/EPAL was good, but URBANSIM provides more flexibility. DRAM/EMPAL provided good tracking at the county level, but did not do a good job in the outlying regions (underestimated growth). Employment forecasts were much better. State and local officials seem to accept the forecast.

SACOG: A developer "module" has been developed whereby development forecasts are reviewed by the local development community. Interviews are conducted to determine if what PECAS and local desires mesh with the acceptable rate of return expected by developers.

With respect to Board members, they do take land use information into account when making decisions. The forecasts are considered very credible. This is partly so because the model results will provide them with "cover" in that generally the results will reinforce the direction they want to go in anyway.

WACOG: COG looked at the 2000 forecasts that were done in the 1970s. Households were right on, and actual employment was 5% higher than predicted. They were way off in the population per HH assumption. At the regional level, officials seem to believe the numbers; at the TAZ level, perhaps there is more u uncertainty.

19. Have your land use forecasts been used to support officially adopted transportation plans and conformity determinations? Have these forecasts ever been challenged legally? If so, on what grounds?

BMC: Land use forecasts are part of the region's transportation planning process, which goes through a conformity process. Thus, indirectly, land use forecasts are part of conformity determinations. However, PECAS has not yet been used in this capacity. The Maryland Department of the Environment is

interested in the numbers due to the conformity issue. No legal challenges have occurred yet.

DRCOG: There has been no link to conformity analysis, no legal challenges.

H-GAC: Land use forecasts are linked to conformity in some minor ways. H-GAC convinced EPA to examine voluntary vehicle emissions reduction programs as a TCM for some satellite cities. There have been no legal challenges; in fact, the environmental community is encouraging H-GAC to do more initiatives like the emissions reduction program. The real tension is that the SIP has a short term focus, whereas the greatest concern should be on the missing investment in infrastructure and land use policies.

Metro: Yes, the forecasts are used to support adopted transportation plans, and there have been legal challenges. Not so much in the transportation arena, but both 1000 Friends of Oregon, City of Portland and the Home Builders Association have taken Metro to court on various aspects of UGB expansion for opposing reasons (too much, too little, not enough affordable housing). So far, expansions based on MetroScope and associated research have withstood legal scrutiny unlike expansions prior to year 2000 that were always over turned in court.

PSRC: Land use forecasts are adopted into the transportation plan, but have not been used in any other way such as conformity determinations. There have been no legal challenges.

SACOG: There have been no legal challenges on land use forecasts. However, travel forecasts have been challenged on conformity, because of the perceived underestimation of benefits from some of the programs in the plan (e.g., SMOGCHECK). SACOG won the lawsuit.

WACOG: The transportation plan does go through a conformity analysis. The environmental groups have "jumped on" the jobs/housing balance character of the plan, but have not yet sued (although there have been threats).

20. How much external technical support to you use in developing, using and maintaining your land use model (e.g., consultants, universities, etc.)? What is your estimated annual cost to maintain your modeling effort?

BMC: Much of the maintenance and running of the model is done in-house. They do use "over-the-shoulder" consultants to make

sure everything works. The staff is perfectly capable of making improvements to the model.

DRCOG: Outside assistance has been limited, primarily the economist producing the regional control totals ($10,000).

H-GAC: H-GAC uses almost no external support for its land use modeling. They did contract the University of Washington in the early years, but this is no longer needed. All model development and integration with other tools is done in-house.

Metro: In 2005 they contracted with PTV America to build VISUM in R Code into MetroScope and port the entire model into R. The contract was for $76,000 roughly. This work has now been substantially completed (they are in "Beta" testing with generation 3.0). This has been the only outside assistance in developing and operating MetroScope. To operate the model at the current level of roughly 10 runs per year requires about 0.75 FTE. This includes data input prep and output analysis, write up and presentation (running the model is probably the least concern as making sure input data and timing assumptions are properly coded and collating and presenting the output continues to be a work in progress). Jurisdiction review if required takes almost as much time as running the model.

PSRC: PSRC contracts with the UW for technical support. They provide $150,000 per year in software support and technical training. This will likely go down once the model is running. The software is open source and thus they don't have to pay any proprietary fees. In addition, the development of URBANSIM has benefited from millions of dollars of grant support from other sources.

SACOG: Since 2000, they have been using outside technical support with model development. The total estimated cost (including staff) for PECAS, travel demand modeling and database development over this time period is $4 million. UC-Davis has worked with them, but did not get financial support. About 33% of this was for data base development, 50% for staff and about 17% for consultant support.

21. What do you consider to be the strengths of your current model?

In general, the MPOs felt that the major strength of their model was that it allowed land use modeling to represent the market dynamics of likely development scenarios in their region. As noted by SACOG, for example, PECAS gets at the "robustness of growth projections." PSRC stated that UrbanSim allowed them to conduct different scenarios, which was considered important for their planning process. Transparency of

process and outcomes was also mentioned by several MPOs. For example, Portland Metro noted, "their approach is transparent in the micro-economic sense of fully reflecting market transactions in its structural equations".....and that accordingly, it is "able to stand up to legal and academic scrutiny." Other strengths offered in the surveys included:

UrbanSim (H-GAC):

- *Better able to integrate with GIS work*
- *Can work, and present, at different geographic detail, getting away from TAZ and relying on appraisal data much more.*
- *Better linkage between transportation and land use decisions.*
- *Easy to train staff.*

UrbanSim (PSRC):

- *Easy to incorporate land use plans and information into database*
- *Geographic scale and temporal forecasts are very flexible.*

PECAS (SACOG):

- *Allows SACOG to educate local officials on the reasonableness of assumptions…and in some cases, the model can get communities to lower their development expectations.*

WACOG does not use a land use forecasting model, but they did list the following strengths of their approach: synchronized regional and local land use planning; engaging locals in growth-related discussions; and a more transparent process.

22. What do you consider to be the weaknesses of your current model?

In almost all cases, the MPOs identified the amount of effort it took to develop, calibrate, operate and maintain the model as one of the major weaknesses of their approach. As succinctly put by Portland Metro, their approach "takes too long to run, requires too much data, is too complex and potentially too disruptive to the business as usual approach to transportation and land use planning."

Interestingly, <u>several</u> MPOs questioned whether the increased (and enhanced) output from their land use model was worth it…as put by PSRC, "are the efforts you are making for "better" forecasts going to make a difference in decision making?"

SACOG also noted that there are some policy issues, such as "aging in place" that are not easily addressed with their model (PECAS).

For WACOG, sometimes forecasts become more of a wish than a real attempt to understand the likely market outcome. Given that the forecasts have to be approved by the COG, there is a slight tendency to push the numbers up….a tendency to "go along to get along."

Your Future Land Use Model

The following three questions are very much related and thus the combined answers are found following #25. Given that the MPOs were chosen for their activities in land use modeling, it was not surprising that many had already adopted an approach toward forecasting, and were not going to change in the near future.

23. Are you planning to change in any significant way how travel demand is modeled in your region? If so, why? How will your land use model change to reflect the input needs of this new modeling approach?

24. If you are not changing your travel demand model, are you planning to switch to another land use model in the near future? If so, why? Which land use models are you considering?

25. If you are not switching to another land use model, are you planning any major refinements or enhancements to your existing model? If so, what changes are you considering and why?

BMC: *No changes expected in the travel demand model. They are almost done calibrating PECAS.*

DRCOG: *Land use DRCOG is going to an activity-based modeling approach. They have developed a model design, and are now doing data estimation process. Their approach will be similar to Sacramento's. Should be operational sometime next year.*

With respect to land use modeling, DRCOG is evolving to UrbanSim. The use of a population synthesizer will be a bridge between land use and transportation modeling. With (x, y) coordinates for every job and household, they will be able to be more specific about land use allocations in places like urban centers.

H-GAC: *No expected changes in travel demand model, nor in the UrbanSim approach.*

Metro: *Metro travel demand runs several models with the aim of moving completely to activity–tour based travel demand models. The land use model output is configured to provide detailed real estate, demographic and economic data at a variety of spatial scales so they anticipate no problems in*

providing the necessary socio-economic details these models require

Their latest refinement is the complete integration of the travel demand and land use models (integration here in a programming sense). They now have the capability of prepare input tables for all of the policies they choose to implement over a 30 – 40 year period including transportation networks at the start of a model run. They can launch the simulation, let it run and come back for the finished product in about 20 – 30 hours. .

PSRC: PSRC is "setting up" to do activity- based modeling, but will not go that direction for at least another 2 to 3 years. A new household survey is underway, and this will be the basis of activity-based model development. If they choose to go this route, the household survey is asking why people made residential choice, so PSRC is looking at the possibility of this information replacing some aspects of URBANSIM.

SACOG: They are not contemplating any significant changes to land use or travel demand modeling.

WACOG: The TPB is researching the use of tour-based travel demand modeling. They are doing a major household survey of 10,000 households and are awaiting what other MPOs are doing in activity-based modeling to see what they want to do. Right now, they are making incremental improvements to their 4-step model.

26. Given the changing nature of transportation planning and the policy concerns it deals with, what new uses (if any) for land use models over the next 10 years do you see for your agency? Do you think land use modeling will become more or less important for your agency over this time frame?

BMC: Land use modeling will be even more important in the future. People are expecting more from technical analysis and thus the transportation/ land use relationship can only become more important. Also, they believe environmental justice/equity issues will become more important, and this has a land use component to the type of analyses that need to be done in this area.

DRCOG: Land use modeling will become more important, especially with an urban growth boundary and urban centers. Also, they expect more emphasis will be placed on non-motorized trip generation as it relates to land use and urban design.

H-GAC: *Land use modeling will become more important in the future, especially with greater sensitivity to risk from hurricanes. There is also increased interest in redevelopment of the urban core.*

Metro: *They are preparing to explicitly evaluate some potential impacts of rising oil prices and the impact of a dramatically aging population. Also, they need to develop land use strategies to minimize the negative impacts of their property rights initiative – Measure 37. They expect land use forecasting to become more important and indeed more controversial once policy makers become accustomed to the range of questions that the models are able to address.*

PSRC: *The land use and transportation relationship will likely become more important in future years, especially as it relates to pricing strategies. The land use component would be looking at the land use implications of new transportation traveler costs. The other key issue in Seattle is that the Growth Management Act has resulted in some communities achieving their targeted growth. What happens to land use patterns when this occurs? Also the land use/transportation models will likely be used more to answer "what if…?" questions.*

SACOG: *The new Blueprint plan will very much be about how development should proceed in Sacramento. Land use forecasting is instrumental in this effort. A corollary is "Greenprint" planning, that is, how to reflect the role of sensitive lands in the forecasting effort. There are clearly lands (e.g., wetlands, historic sites, etc.) that are untouchable. Other lands are not in the boundary of the Blueprint designs and are not environmentally sensitive. However, there are "in-between" lands that need to be addressed within the modeling framework.*

Other issues that will become important:

--residential dynamics: can we forecast the moving or staying decisions of households? Same issue with jobs

--Goods movement: what about the location dynamics of light industrial uses and their being affected by interregional/international/state economic dynamics.

--Suburban refit: we want to make them more compact to be better served by transit; can models show this response and help convince local officials to take this policy approach?

WACOG: *The Regional Mobility Study discusses some of the changing trends and issues that relate to land use. The MPO needs to think differently, e.g., looking at a regional network of HOT*

lanes. The pressing question is how to develop a "composite scenario" from the different scenarios being tested?

27. Which MPOs do you think are "doing a good job" in integrating land use modeling and small area forecasts with their transportation planning effort?

MPOs mentioned included: Dallas-Ft. Worth, Houston, Nashville, Portland, Sacramento, San Diego, Seattle, smaller MPOs in Florida

For comparative purposes, we would also like to obtain the following information for your planning area: population, land area, number of traffic analysis zones (used in travel demand modeling) and links in your transportation model, and average superdistrict size. What kind of geographic hierarchy do you use in your modeling efforts, i.e. districts, census tracts, traffic analysis zones?

BMC: *2.5 million population*
1,151 TAZ's
950 Census blocks

DRCOG: *2.6 million people*
5000 mi^2
2,664 TAZ's
About 13,000 two-way links

H-GAC: *5.5 to 6 million people*
8 county area about 8,000 mi^2
3,500 TAZ's
18,000 (two-way) links
Super-districts are really the counties, although Harris County is subdivided into several sub-districts defined by Interstate highway boundaries. There are about 24 major sub-districts in Harris County.

Metro: *2 million*
3,700 sq. miles
2029 taz's
Average E zone 50,000 employees, 35,000 HH.
Geographic hierarchy – 20 District, E-Zone, R-Zone (census tract). (all of these nest upward from the Census tract) and finally TAZ. The TAZ's have boundaries drawn on street travel sheds and do not correspond to other geographies (i.e., they do not nest into census tracts).

PSRC:	*3.4 million population.* *4 counties* *219 large areas for aggregation* *52 larger areas for aggregation* *16 largest areas for aggregation* *938 TAZ's* *19,056 links in network*
SACOG:	*2.2 million people today; 3.2 million in 2030* *6 county area about 6,700 mi^2* *3,500 TAZ's* *23,000 to 25,000 (one-way) links* *1,300 TAZ's (but may be going to 1,500 TAZ's)* *850,000 parcels*
WACOG:	*4.6 million population* *3,000 mi^2* *About 2000 TAZs* *About 35,000 to 40,000 one-way links*

2.2 Overview of the Evolution of Land Use Forecasting in Each Region

Baltimore Metropolitan Commission

The region has always been interested in land use modeling, and this interest has evolved overtime. In the 1970's, the model used was EMPIRIC. By the 1990's, the Baltimore Metropolitan Council (BMC) had looked at several different models, including MEPLAN, TRANUS and several other models. One of the problems with TRANUS (which was the model they were most interested in) was securing technical support. The results of preliminary TRANUS runs were presented to local planning directors, and the reaction was very negative---they did not like the inputs or the model in general. BMC planners, however, felt that this reaction was not so much a statement on TRANUS as it was on the overall land use modeling effort in general. In particular, local officials had real difficulties with the type and quality of local data input. Accordingly, BMC set aside funds in the UPWP to support an effort to improve local data input.

By the 2000, BMC chose PECAS as the model that would be adopted. They are almost done with their calibration; they should have their first calibrated run by December 1st.

The costs in adopting a new model were about $60,000 of consultant support, with a total estimate, including staff time, of about $300,000. This does not include the amount of staff time for the continuous data collection and data cleaning effort.

Denver Regional Council of Governments

The model DRCOG currently uses, and has used for the past 13 years, was described by Erik as a "home grown" DRAM/EPAL model. It is not the same DRAM/EPAL that is used by ARC in that DRCOG did not like the original formulation of the model, so they adopted key concepts from DRAM/EMPAL, and developed their own approach. This evolution in model development has occurred primarily when new staff members (in particular, economists) were added to the staff. The last significant model upgrade occurred in the late 1990's.

A utility function is developed for each zone and related to the "capacity" of that zone as provided by local government officials. The zones with the highest utility scores get the fastest growth rate in using up its capacity. Lower scores result in lower growth rates. There is no tie between an increase in households and an increase in employment <u>at the zonal level</u>. There is at the regional level where the model follows the traditional industry/service allocation first followed by population.

Houston-Galveston Area Council

H-GAC looked at DRAM/EPAL many years ago and adopted it as developed by Putman. However, they outgrew the original formulation in terms of their needs. The model did a good job at the regional level, but had difficulty in producing good results at lower levels of disaggregation. They switched to UrbanSim five to six years ago, and they have been very satisfied so far.

The general approach followed in their land use modeling is to first use an econometric model to develop regional control values, and secondly to distribute households and employment via UrbanSim constrained to county control values.

Portland Metro

Portland Metro originally contracted for DRAM-EMPAL in 1992 on the advice of a consulting team associated with the LUTRAQ effort. Subsequently, due to their unique needs associated with Urban Growth Boundary planning they developed their own in-house spatial allocation model named SAM. While serviceable for trend analysis, it became clear that spatial allocation models were inherently unusable for policy analysis. In 1996, they began a part time conversion over to an in-house developed model that eventually by the year 2001 became an early version of the MetroScope model now in use. Development of the residential and nonresidential modules of MetroScope occupied about 0.2 FTE over a 4-year period. Ongoing model operation and version upgrades occupy about 0.8 FTE spread over 2 employees – a principal and an assistant planner.

They use a 6 county demographic and economic forecast produced in house as the control total starting point. For each 5 year forecast period, MetroScope allocates residential and nonresidential real estate development to 425 R-zones and 72 E-zones for a variety of real estate types. The model's demand equations populate the real estate stock with households by age, household size, income and school age children present and the nonresidential stock by 15 types of employment. MetroScope uses a post processor to allocate the control totals by R-zone and E-zone to TAZ's, though local jurisdictions are responsible to ensure the final TAZ allocations.

Puget Sound Regional Council

Prior to 1980, this region used the EMPIRIC model; from 1980-1982 it transitioned to DRAM/EMPAL and from 1985 to 2002 DRAM/ EMPAL was the major model. From 2002 to today, PSRC has been transitioning to URBANSIM. The cost to PSRC of this transition has been about $1.3 million, and 2 FTEs devoted solely for that purpose.

Sacramento Area Council of Governments

SACOG has traditionally followed an approach toward land use forecasting that Pete called "policy-based projections," which meant that they use local plan inputs and the results of development monitoring to keep their land use database up-to-date. There seems to be heavy reliance on local input on desired land use characteristics. SACOG does "negotiate" a cap on local population and employment forecasts. The state Department of Finance provides a control value that is a ballpark estimate of total population, but SACOG isn't sure that these control values are very good.

By the mid-1990s, SACOG went through its DRAM/EMPAL phase, in that they examined using DRAM/EMPAL including bringing Putman out to discuss the model. They did not use the model because they were not "comfortable" with its approach. However, this experience did show them the value of having a much finer classification of employment (6 categories instead of the retail/non-retail) they used before. The quality of employment forecasts seemed to be much better and the translation to what was really happening in the economy made sense.

At the same time the flirtation with DRAM/EMPAL was underway, Bob Johnson at UC-Davis was developing a research model (MEPLAN) that was based on Sacramento data. SACOG did a study looking at the differences among TRANUS/MEPLAN/DRAM-EMPAL and decided that MEPLAN was the best approach for what they were planning to do in the early 2000's.

In 2002, SACOG developed its Blueprint Plan that was going to examine a variety of land use and transportation strategies for the region. The research version of MEPLAN was used to model the sprawl scenario, and additional data were collected to conduct this base line analysis. The Board was not really happy with the Blueprint Plan because it really did not look seriously at alternative land use visions. There wasn't really a tool for doing this, and yet the Board felt this was were the region was going. In updating the transportation plan, the Board wanted to look at three scenarios—a maximum transit investment scenario, a balanced transportation scenario, and a redirecting development scenario. However, SACOG really didn't have the tools to do the latter.

To develop some capability to do land use scenarios, SACOG adopted PLACES, which was used at the parcel level for different development types to determine different urban design futures. Fifty different development types have been used since PLACES was first introduced (over 3 years). It was used to look at different growth rates, development types (greenfield vs infill, etc.). PLACES is still used as input into scenario definitions.

In the meantime, MEPLAN is being replaced by PECAS. In 2001, SACOG did a household survey that was intended to lead to a new transportation demand model. They are going to a tour-based, activity modeling structure. PECAS is intended to look at what will happen over different time periods, and PLACES parcel data is the input data. The Blueprint Plan effort did divert

resources from a full scale implementation of PECAS, but the parcel definition through PLACES did represent an initial step toward the modeling effort, which they are now finishing.

Thus, the current situation in Sacramento is that they are using PLACES and soon will be using PECAS. They are just beginning the calibration process for PECAS. However, they are looking forward to the economic forecasting ability of PECAS.

Washington Council of Governments/Transportation Planning Board

In the early 1970's, WashCOG used EMPIRIC, which was universally considered a dismal failure, especially by the local governments. In 1975, the COG established a "cooperative forecasting process" that Robert Griffiths described as both top down and bottom up. The top down portion of this approach is the use of a regional econometric model to derive regional control values for the MSA by employment sector. This leads to an estimate of the number of workers and the labor force required, which then allows them to estimate population and households.

Two key issues have arisen in this estimation process, how will the labor participation rate change over time in different employment sectors? And how to represent those either self employed or holding multiple jobs? A technical COG subcommittee consisting of demographic and economic staff of local major jurisdictions conduct research for the region on such issues. This group meets monthly. The subcommittee very much enjoys this approach toward forecasting and indeed has brought in many speakers from the BEA, Census, and BLS to discuss the forecasting process.

The population and employment forecasts, and concomitant subarea and TAZ forecasts, are called "Rounds." Thus, the first round occurred in 1976, and subsequent rounds occur every 3 to 4 years. However, it is customary for local jurisdictions to update their land use database annually. For example, Round 7a, that latest effort, included some minor changes in some TAZs because of the new baseball stadium being built in D.C. (thus the "a" in the Round number).

The bottom up part of the process is that local jurisdictions, that is, the same people who sit on the cooperative forecasting subcommittee develop their own jurisdiction's small area and TAZ forecasts. They look at building permits, development patterns, etc, and provide to COG the TAZ –level estimates. <u>Thus, there is no land use model used at the regional level to distribute population and employment forecasts.</u>

The small area projections are summed across the entire region and then compared to the regional control values…if the numbers are within 3% of the

control value, COG "declares victory." If not, the subcommittee negotiates to get a regional distribution.

Round 1 was the toughest application of this process, because most of the jurisdictions assumed that they would receive their maximum growth potential. The biggest issue was the assumed growth in D.C. versus the suburbs. However, COG thought the process worked well because it was not COG staff questioning the numbers, it was the local staff peers questioning the numbers. And for the most part, these debates have been based on technical merits.

For example, Round 3 (early 1980s) the econometric model assumed a decline in federal employment (which was occurring during the Reagan years) and generally made pessimistic assumptions about future growth in D.C. Within a year of the forecasts being accepted, the 2010 estimates were being exceeded in the District. The locals have not forgotten this experience with the model.

Rounds 4, 5, and 6 worked well, with the model results being accepted as being pretty valid. Round 6, however, showed a problem with assumed numbers of commuters coming into the region from outside the MSA. In essence, the COG had to assume a lot of commute trips coming into the region to meet what the expected travel demand was going to be. This set up a large imbalance between productions and attractions. In Round 7, this issue was looked at very carefully and COG looked at the next set of outlying counties (outside their study area) and other external areas and asked whether these areas were assuming the level of growth that would support a travel pattern assumed for the WashCOG area. What COG found was that they were not. It turns out that WashCOG must use the Baltimore Metropolitan Council's and Fredricksburg MPO's forecasts without changing them. When doing so, the travel land use assumptions did not "add up."

A closer examination of what was going on showed that local jurisdictions when they produce their local forecasts did not assume much redevelopment of existing land use after 2020, and given that many of the "Greenfield" sites were used up by 2020, the demand had to come from somewhere…and thus the assumption that it would come from external to the region. Given the inconsistencies among the COG, BMC and Fredricksburg MPO's forecasts, COG had to either reduce the job forecasts in its study area or increase the amount of employment density…..the choice has been to increase the amount of employment density and this is reflected in the local jurisdiction's forecasts.

3. Evaluation of MPO Surveys based on MPO Interviews

Answers to the supplemental technical questions asked in the MPO interviews provide some information for evaluating how well the models satisfy evaluation criteria identified in the literature review. The following table organizes this information for each of the three model systems in use or under development that ARC might consider acquiring. It does not include information about the DRCOG land use model, which is home grown and being abandoned in favor of UrbanSim. The interview notes provide information about that model, as well as additional details for the three models compared here.

	EVALUATION CRITERION	PECAS (BMC and SACOG)	URBANSIM (H-GAC and PSRC)	METROSCOPE (Metro)
1	In ongoing use in 2 or more locations. This demonstrates that the implementation is transferable.	NOT QUITE. BMC indicates that they are now using PECAS. Extensive design and development have been done in Sacramento, but they are still quite a way from using it. So, PECAS does not satisfy this criterion, but it comes close, and its framework is definitely transferable.	NOT QUITE. H-CAG used UrbanSim for its 2003 RTP, and is using it for the current RTP development. Extensive design and development have been done at PSRC. They want to start using it, but have some significant work yet to do. UrbanSim does not satisfy this criterion, but it comes close, and its framework is definitely transferable.	NO. MetroScope is only in use at Portland Metro. However, PTV America is implementing with them a version with a simple integrated transport model, that is intended to be transferable to other locations.
2	Calibrated and in ongoing use in at least one location. This demonstrates that the developer can actually make the chosen modeling approach work.	PROBABLY. BMC indicates that they are now using PECAS. BMC was not available to answer technical questions, so it is somewhat hard to assess its degree of calibration and use.	YES BUT... H-CAG used UrbanSim for its 2003 RTP, and is using it for the current RTP development. The latest work is being done with a new version of UrbanSim, and it sounds like it will continue to be enhanced and recalibrated on an ongoing basis for some time to come. It is very clear that UrbanSim is a work in progress, with many rough edges. Some major components, like the base year population synthesizer and the mechanisms to update the population for forecast years, don't work well or consist of temporary approaches that yield outputs but not very good ones.	YES. MetroScope has been used for years at Metro.
3	Builds on an approach that the developer has implemented successfully.	YES. Although PECAS is new, it builds on the MEPLAN approach, which Hunt and Abraham have successfully implemented.		
4	Real estate demand and prices are endogenous. This seems to have become a standard in urban models.	YES	YES, BUT The effectiveness of the UrbanSim price mechanism is not clear.	YES

	EVALUATION CRITERION	PECAS (BMC and SACOG)	URBANSIM (H-GAC and PSRC)	METROSCOPE (Metro)
5	Interfaces effectively with an external travel demand model.	YES, BUT... PECAS works with an external travel demand model, but neither BMC nor SACOG gave clear answers regarding what outputs from the transport model are used as PECAS input. Materials produced by the PECAS developers suggest that a logsum from the mode choice model is used.	YES, BUT... INTEGRATION: H-GAC's version does not iterate with their transport model, but this is because the two models are run by different departments. Each department uses outputs from the other department's model as its inputs, but they come from the other department's previous run of their model. They are in the process of integrating the two models. At PSRC, UrbanSim runs every year, uses new transport generalized cost every 5 years, and uses a new transport network and costs every 10th year. UrbanSim could use new values every year, but they do it this way to reduce processing time. INPUT FROM TRANSPORT MODEL: At H-GAC, UrbanSim uses travel time skims directly, as well as mode choice logsums (as a cost proxy) and measures of physical proximity to transportation facilities. Transit and toll costs would come via the logsums, to the extent that these variables are included in the mode choice model. H-GAC has not tested UrbanSim sensitivity to transit and toll costs. At PSRC, they have experimented with using mode choice logsums and highway generalized costs. UrbanSim would be sensitive to transport through one of these; if generalized cost is used instead of logsum, then it would not be sensitive to parking costs and transit LOS.	YES, BUT... INTEGRATION: MetroScope is integrated with their travel demand model, running iteratively. It uses mode-weighted logsums from the travel demand model, usually lagged by 5 years. INPUT FROM TRANSPORT MODEL: MetroScope's mode weighted logsums take into account costs, travel times, parking charges, transit, other modes, etc....whatever is accounted for in the travel demand mode choice model. The MetroScope version being implemented by PTV includes a fully integrated, simplified travel demand model, so it apparently will not interface with the regular travel demand model.

	EVALUATION CRITERION	PECAS (BMC and SACOG)	URBANSIM (H-GAC and PSRC)	METROSCOPE (Metro)
6	Extent and detail of required exogenous forecasts of household demography, employment, etc. Better if the model generates the details internally, but it must do it well; if it requires detailed external inputs, then they must be generated somehow (see discussion in text).	At SACOG PECAS uses exogenous regional controls of population, housing and employment. It also uses development policies and developer costs by jurisdiction.	H-GAC uses exogenous county-level control values. I'm not sure of the reason; UrbanSim doesn't require it. It would be good to determine if they are doing it because UrbanSim failed to provide credible forecasts by county. H-GAC has supplied a document detailing the procedure. They apparently run "separate" versions of UrbanSim for each county. At PSRC, UrbanSim uses regional controls for jobs by sector, population and households. PSRC produces independent county level forecasts of these to compare to UrbanSim forecasts. At both H-GAC and PSRC, UrbanSim requires input on developable land at the parcel level, as well as other scenario information such as proximity to transport network.	MetroScope uses exogenous regional controls of households by size, income, age and presence of children, and of employment by up to 15 categories (aggregated from their forecasts of 30 NAICS classes.) MetroScope also requires exogenous input regarding the stock of land: market availability, zoning designation and capacity.

	EVALUATION CRITERION	PECAS (BMC and SACOG)	URBANSIM (H-GAC and PSRC)	METROSCOPE (Metro)
7	Geographic disaggregation of outputs, and disaggregation of households demographically, and of employment categorically, in categories most useful to the travel demand models (see discussion in text).	BUILDING ATTRIBUTES SACOG PECAS developer model forecasts parcel level building inventory data in 8 commercial and 4 residential categories. HOUSEHOLDS & EMPLOYMENT BMC PECAS distributes employment forecasts at the TAZ level, distinguishing blue and white collar and all major employment sectors. In PECAS, households and employment are modeled at in the aggregate spatial IOmodel; the SACOG version uses 650 zones that are an aggregation of their TAZ. For each TAZ employment is in 29 categories and households are in 16 income categories.	GEOGRAPHY H-GAC UrbanSim outputs are for 1000x1000ft grid cells, and are aggregated to TAZ and other levels for use outside UrbanSim. At PSRC the UrbanSim outputs are for 5.5 acre grid cells. Outputs are aggregated to TAZ and county. BUILDING ATTRIBUTES PSRC building output attributes INCLUDE sq ft, type, value and units HOUSEHOLDS & EMPLOYMENT Although H-GAC UrbanSim uses ethnicity, age of head, income and various other demographic variables, **it does not change the income distribution (and perhaps the distribution of other HH characteristics) through the forecast periods. It provides only number of persons, number of households and employment by sector to the travel demand model**. The travel models make their own assumptions about demographic distribution. H-GAC UrbanSim outputs employment in 7 SICs. They created their own post-processor to transform them 8 employment categories for the travel model. Note that UrbanSim allows the user to choose the categories. PSRC travel model uses a cross-classification of UrbanSim HH by number size, income & number of workers. For school trips it uses a classification of HH by number of school age children, and for college trips it uses a classification of HH by number of college age persons. The validity of these output distributions has not yet been validated. PSRC UrbanSim forecasts employment by 18 sectors	BUILDING ATTRIBUTES MetroScope outputs 4 residential housing/tenure types for 425 zones, and 6 non-residential building types for 72 zones. HOUSEHOLDS & EMPLOYMENT MetroScope outputs household information for the 425 zones by 400 classes by 4 building types. The classes are HH size (5), income (8), age (5), school age children present (2). Employment output is for 72 zones by 15 NAICS types by 6 building types

	EVALUATION CRITERION	PECAS (BMC and SACOG)	URBANSIM (H-GAC and PSRC)	METROSCOPE (Metro)
8	Data required for calibration. It is not very clear from the literature review how different the data requirements are among the models.	SACOG PECAS required households, population, employment, local plan information, an environmental GIS layer, assessors' data, and a parcel-based redevelopability attributes (primarily age of structure).	UrbanSim requires base year parcel (or grid cell) data The required data includes employment by sector, housing units, nonresidential square footage, land value, improvement value, land use category, developability restrictions. UrbanSim requires a base year synthetic population. UrbanSim requires trend data in parcels and employment for model calibration.	MetroScope requires base year "observable" initial conditions, including housing and nonresidential real estate stock and the transportation network. Housing and location choice and price data are required to estimate parameters of residential demand equations. Choice and aggregation patterns are needed to estimate non-residential demand equations. Residential and nonresidential supply equation parameter estimation requires initial land value and construction cost data. Data comes from census PUMS, survey of Consumer Expenditures and Metro's Regional Land Information System.
9	Ease and speed of operating the calibrated model	?	?	?
10	Ability to effectively use the new population synthesizer.	With PECAS, ARC would probably use the population synthesizer for forecast years. The forecast year synthetic population would be a bridge between PECAS and the travel demand model. PECAS would provide control values for the synthesis, and the travel demand model would use the synthetic population in trip generation or for activity based travel demand microsimulation.	UrbanSim requires a base year synthetic population, and there are problems with the current UrbanSim population synthesizer, so the ARC PopSyn would likely be used to generate the base year UrbanSim population. For forecast years, there are acknowledged weaknesses of UrbanSim's use of the synthetic population. It is hard to tell what the UrbanSim developer will do to improve this UrbanSim feature, and whether it might include the use of a population synthesizer	With Metroscope, ARC would probably use the population synthesizer for forecast years. The forecast year synthetic population would be a bridge between MetroScope and the travel demand model. MetroScope would provide control values for the synthesis, and the travel demand model would use the synthetic population in trip generation or for activity based travel demand microsimulation.

	EVALUATION CRITERION	PECAS (BMC and SACOG)	URBANSIM (H-GAC and PSRC)	METROSCOPE (Metro)
11	Ability to effectively interface with a new activity-based model.	For each residential zone, PECAS forecasts households by income and jobs (in the zone of residence) by type by household income. It doesn't forecast households by size or by number of workers, or information about age or presence of children. It would probably be necessary to provide supplemental demographic forecasts at as small of geography as could be trusted, to provide supplemental controls for household synthesis. The PECAS employment forecasts would work well for an activity-based demand model, although it would be necessary to disaggregate the employment forecasts at least to the TAZ level for either a trip-based or an activity-based travel demand model.	UrbanSim's disaggregate geography is very well suited to an activity based model. However, there are indications that it cannot accurately forecast the distribution of basic household characteristics required by either a trip-based model or an activity-based model, let alone the additional characteristics that an activity-based model could take advantage of.	The current version of MetroScope would naturally fit well with an activity-based model because of the detail provided for controlling population synthesis, although the validity of that detail is uncertain. Also, the employment data is quite aggregate, so it would require a method of disaggregating employment outputs to the TAZ level. Since the "street" version being developed will have an embedded simple travel demand model, it is not clear that it would work well with a new activity-based model.