Investigation of Land Use Model Application in the United States

Chapter 2

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Abstract: Metropolitan Planning Organizations have come under intense pressure to respond to federal mandates to link planning of land use, transportation, and environmental quality; and from citizen concerns about managing the side effects of growth such as sprawl, congestion, housing affordability, and loss of open space. Land-use modeling has been implemented in various ways in these organizations. This chapter presents the present situation of land use modeling in the United States.

1. INTRODUCTION

Since 1990 there has been renewed interest in urban models due to several governmental/federal requirement/legislation to realize linkage between land-use and transportation in urban planning. In the United States (TMIP, 1997): the Clean Air Act Amendments of 1990, the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), and the 1998 Transportation Equity Act for the 21st Century (TEA21) require that the Metropolitan Planning Organizations (MPO) integrate the metropolitan land-use and transportation planning in to a single framework. In the United Kingdom: the Standing Advisory Committee on Trunk Road Assessment (SACTRA) was asked by the Secretary of State for Transport to consider the effects on the performance of the economy, which might be caused by transport projects and policies, including new infrastructure, changing prices, demand management and measures to reduce traffic. Similarly, in Japan: the Ministry of Land, Infrastructure and Transport that is responsible of road transportation planning and its implementation has initiated R&D projects to improve forecasting system that incorporates impact of land development.

Nearly 30 years after Lee (Lee, 1973) signaled the demise of the large scale urban model, vastly improved computers, databases, GIS and demands of planning policy have made possible the integrated urban models that are explicitly market based and structurally consistent with urban economic theory. Several models have been developed and implemented: MEPLAN (Hunt, 1993, 1994, Williams, 1994, Echenique, 1990, 2000), and DELTA model (Simmonds, 1998, 1999) in Europe; TRANUS (de la Barra, 1989) in Latin America, Mussa model in Chile (Martinez, 1992, 1996), RURBAN in Japan (Miyamoto, 1985, 1996). In North America, although DRAM/EMPAL is the majority of land-use model being applied, new models with more theoretical consistency are being developed and implemented in several locations (Hunt, 1999). As one of the most recent attempt in USA, Waddell (Waddell, 2001, 2002) is implementing UrbanSim models in several U.S. regions. Table 1 below summarizes some of the recent applications of the urban models in several countries and cities around the world.

Table 1 Some of Urban Model Applications

Land Use	*Transportation*	*COUNTRY / City*
DRAM/EMPAL	TRANPLAN, MINUTP, EMME/2, TRANSCAD	USA: Atlanta, Chicago, Dallas, Detroit, Houston, Kansas City, Los Angeles, Orlando, Phoenix, Portland, San Francisco, Sacramento, Seattle, Washington DC
MEPLAN, MENTOR	MEPLAN, EMME/2	UK, SPAIN, ITALY, GERMANY, SWEDEN, FINLAND, CHILE, CANADA, SOUTH AFRICA, BRAZIL, JAPAN, European Region, Scottish Borders, USA: Sacramento
TRANUS	TRANUS	VENEZUELA, FRANCE, BELGIUM, SWITZERLAND, SPAIN, PANAMA, PARAGUAY, COLUMBIA, DOMINICAN REPUBLIC, GUATEMALA, UK: Swindon, Inverness, USA: Oregon statewide, Baltimore, Salt Lake City, Honolulu, Sacramento
DELTA	START	UK: Edinburgh, Manchester, Trans-Pennine Region
URBANSIM	EMME/2	USA: Oregon, Utah, Hawaii, Texas
POLIS	MINUTP	USA: San Francisco Bay area
CALUTAS	CALUTAS	JAPAN: Tokyo, Okayama, Nagoya
RURBAN	RURBAN	JAPAN: Sapporo, Sendai

2. MOTIVATION OF LAND-USE MODELING

This section describes the context and motivations for integrated urban modeling. There are two main motivators. The first is the transportation planning context, in terms of the proscribed legal (policy) framework and the second is the modeling context, which is one of the means that is required to implement the transportation planning framework. In this regard, the Travel Model Improvement Program (TMIP, 1998) is the key.

In terms of legal requirements, three Federal Acts are of primary relevance. These are as follows.

- ISTEA the 1991 Intermodal Surface Transportation Efficiency Act
- TEA-21 the 1998 Transportation Equity Act for the 21st Century, which succeeds ISTEA
- CAAA the 1990 Clean Air Act Amendments

2.1 ISTEA

When it became law in December 1991, ISTEA fundamentally altered transportation planning in the United States. As Marshall (1997) explains, ISTEA changed the federal rules that govern state and metropolitan transportation planning. ISTEA has decentralized the former "top-down" transportation planning approach, in which federal mandates largely influenced the timing and location of new state highway construction, in favor of strengthening local and regional authority in transportation planning and decision making.

Weiner (1997) summarizes the relevant aspects of ISTEA and other relevant legislation governing transportation planning. ISTEA required metropolitan planning organizations (MPOs) to develop a 20-year metropolitan transportation plan. This long-range plan had to be based on a financially affordable and integrated1transportation system. Opportunity had to be provided for public input. The plan was to maximize use of the existing transportation system in finding ways to relieve congestion. In non-attainment areas, the plan also was to be coordinated with the development of transportation control measures that are required under the CAAA. The long-range plan had to be updated periodically.

Under ISTEA, the development of an MPO's long-range transportation plan had to take into account 15 interrelated factors. The fourth of these requires some integration of transportation plans and land use plans. Specifically:

"the likely effect of transportation policy decisions on land use and development and the consistency of transportation plans and programs with provisions of all applicable short-and long-term land use and development plans."

ISTEA also required states to develop a continuous statewide transportation planning process, based on that used by MPO's for metropolitan transportation planning. A long-range, integrated, multi-modal statewide transportation plan had to be prepared. It was to be coordinated with metropolitan transportation plans, and it was to allow for public input. As with metropolitan transportation plans, the statewide plans had to consider 20 factors, of which the 14th was as follows:

"the effect of transportation decisions on land use and land development, including the need for consistency between transportation decision making and the provisions of all applicable short-range and long-range land use and development plans."

2.2 TEA-21

ISTEA's authorization of surface transportation programs expired in September 1997 (although funding allocations were extended to the spring of 1998). TEA-21 ISTEA's replacement provides authorization for surface transportation programs for another 6 years. TEA-21 builds on ISTEA's initiatives, although in some cases with different emphases. Of relevance to integrated modeling, TEA-21 retains the general structure of metropolitan and statewide transportation plans described above. It recognizes the land use-transportation relationship, although this is considered in the broader context of economic developmental, environmental and "quality of life" issues.

Both ISTEA and TEA-21 require transportation plans to conform to CAAA requirements, thereby linking land use, transportation, and air quality. However, neither ISTEA nor TEA-21 specifies how the land use-transportation integration is to be achieved. TEA-21 does specify that "mass transportation supportive existing land use policies and future patterns, and the cost of urban sprawl" be considered explicitly in the decision-making (justification) for a "new fixed guideway (transit) system or extension of an existing fixed guideway system."

2.3 Clean Air Act Amendments (1990)

The 1990 CAAA built on previous versions of the Act. The 1990 amendments expanded the Act's conformity provisions (i.e., to attaining ambient air quality standards). A conformity determination was required, in order to ensure that federally approved or financed (in whole or in part) projects or actions conformed to a state implementation plan (SIP). SIPs are actions aimed at reducing vehicular emissions, in order for a metropolitan area to achieve National Ambient Air Quality Standards (NAAQS). The 1990 amendments required that transportation investments proposed by state DOTs or MPOs did not generate new violations of NAAQS or cause delays in the achievement of NAAQS (through the SIPs). The amendments also recognized that air quality must be analyzed quantitatively across the entire transportation system and could be controlled most effectively through regionwide strategies.

Thus, in effect, long-range transportation plans must show conformity to air quality control plans. The 1990 CAAA also expanded sanctions for federal-aid highway projects (i.e., if it was determined to increase emissions contrary to the SIP). At the same time, projects that could be seen as better managing or reducing automobile traffic (thereby controlling emissions) were exempted from sanctions, including transit capital projects.

2.4 Implications

In summary, four key points can be made from these three legal requirements as follows.

- ISTEA established a formal requirement for linking land use and transportation planning, although the TEA-21 is less clear. Land use plans, of course, remain under local jurisdiction. Metropolitan and statewide transportation plans are under the jurisdictions of MPOs and state DOTs, respectively; but are governed by federal legislation and funding requirements.
- The means of meeting the cited ISTEA/TEA-21 requirements are left unclear. Given the different jurisdictional mandates involved, there may have been no practical way of being clearer. However, land use planning is taken into account in transportation funding for specific transit capital projects.
- Together with CAAA, ISTEA established a link among land use planning, transportation planning, and air quality. An important way of improving air quality is to reduce the demand for travel.3 One way of achieving this is to introduce land use plans that promote alternatives to the automobile (e.g., through mixed-used, high-density development; transit- and pedestrian-friendly environments; and so forth).
- There is a corresponding need for analytical tools and data that can support the land use-transportation-air quality link. The dynamics of the link, and of the consequences of different actions, are not fully understood.

2.5 Improvement of Travel Modeling Capabilities

The Travel Model Improvement Program (TMIP) was established by the U.S. DOT and the U.S. Environmental Protection Agency (EPA) in 1993. The program constitutes the most fundamental restructuring of transportation modeling in several decades. TMIP is driven in part by the legal need for improved methods to address the transportation-air quality relationship and by the recognition that the traditional transportation modeling algorithms are not sufficiently responsive to current transportation issues. These needs coalesced with advancements in our understanding of travel behavior (e.g., in random utility-based models, activity-based models, advanced econometric methods for model estimation, and microsimulation). Finally, TMIP takes into account significant improvements in computing, including hardware and software and, especially, data and data management capabilities (notably, geographic information systems; GIS).

A key TMIP product is a new prototype travel demand model (TRANSIMS), which is now under development. This is the focus of one of six TMIP "tracks." One track ("E") is devoted to ways of improving modeling capabilities and data for analyzing the land use-transportation interaction, in the context of the overall TMIP improvements to travel demand forecasting. Whereas the other TMIP tracks could be described as focusing on the transportation-air quality relationship, Track "E" looks at the land use-transportation part of the chain. The inclusion of Track E in TMIP recognizes both the importance of upgrading the existing capabilities for integrated land-use - transportation modeling -- current American models are almost 20 years old -- and the relative lack of understanding of the relationship between land-use and transportation (notably, in the relationship of individual and household activity patterns to travel demand). Track E explicitly recognizes the importance of feedback loops between land-use and travel demand forecasting models, and the need to provide improved land-use inputs to the travel demand forecasting process.

Important finding from Track E are the suggested improvements to existing models and for the development of new models. Issues and concerns that were identified are as follows: (Shunk *et al.*, 1995):

- Most existing integrated models are not sufficiently sensitive to policy issues.
- Most models are not easily understood by other participants and decision-makers in the planning process (politicians, senior government officials, non-modelers, developers, the public, etc.).

- Existing land-use models are not sufficiently well linked to travel demand or environmental models to allow a valid assessment of the interaction among land-use, transportation and environmental impacts.
- There is little agreement on the theoretical underpinnings of existing integrated models, and on their application.
- Generally, there is insufficient behavioral content in existing land-use models.
- Land-use models generally have an overly strong dependency upon travel demand model inputs and assumptions, with insufficient interaction between the two.
- The role that models play in the decision-making process should be reviewed.
- Any new or enhanced integrated models should have a clear, graphical orientation, in order to provide decision-makers and other participants more meaningful information.
- Linkages to a broader set of planning issues (police, health care, services, open space, schools, etc.) also would be useful.
- Data limitations represent considerable problems to the use of existing models. Problems were cited in the availability of reliable disaggregate data by household type, as well as the need to provide appropriate and reliable information as input to the TRANSIMS microsimulation efforts.
- Transit is not represented adequately in land-use or travel demand forecasting models.

3. INVESTIGATION OF LAND-USE MODELING IN MPO

Much of the literature focuses upon the "supply" side of integrated land-use models, i.e., theory, algorithms and technical aspects but there exist very few literatures about "demand" side of the models such as how the models are being used. This section reports the present situation of land-use modeling in the US's MPO. The report is an up-to-date version of the existing reports by TMIP (1998) and MAG (2000) where the relevant information has been updated.

3.1 Seventeen Metropolitan Planning Organizations

The state-of-the-practice of land-use modeling of 17 MPOs is reported here. The areas serviced by these MPO's are considerably differentiated in many aspects such as by size, economic structure (i.e., fast-growth and slower-growth cities), transit- or auto-orientation, integration of land-use and transportation planning and the role of models in planning decisions (land-use and/or travel demand models). They are listed as follows:

1. Middle Rio Grande Council of Governments (New Mexico)
2. Atlanta Regional Commission (Atlanta)
3. North Central Texas Council of Governments (Dallas)
4. Denver Regional Council of Governments (Denver)
5. Houston-Galveston Area Council (Houston)
6. Regional Transportation Commission of Clark County (Las Vegas)
7. Southern California Association of Governments (Los Angeles)
8. Southeast Michigan Council of Governments (Michigan)
9. Metropolitan Council of Twin Cities (Minneapolis)
10. Mountainland Association of Governments (Utah)
11. Maricopa Association of Governments (Phoenix)
12. Metro Transportation Planning (Portland)
13. Sacramento Area Council of Governments (Sacramento)
14. Wasatch Front Regional Council (Salt Lake City)
15. San Diego Association of Governments (San Diego)
16. Association of Bay Area Governments (San Francisco)
17. Puget Sound Regional Council (Seattle)

These MPO's were selected for this report based on availability of information.

3.2 Points of the Investigation

The report emphasizes on the modeling practice of MPOs in response to the federal air-quality conformity requirement. Three groups of consideration are socioeconomic modeling, transportation modeling, and air quality/transportation conformity modeling. The detailed items are listed as follows.

Socioeconomic Modeling

Regarding the socioeconomic modeling, the following items were investigated.

1. Agency responsible for socioeconomic modeling in the region
2. Total population in the region
3. Total land area in the region
4. What has the average annual rate of population growth been over the last 5 years?
5. What is the general methodology used to generate regional/county level population and employment?
6. How often are the adopted population and employment projections generated? What is the time horizon for the projections?
7. What levels of geography does the model use? How many zones are there?
8. Land use models - the current model
9. Land use models - the future model if planned
10. Land use modeling categories - Household, Employment, Land
11. Is there a travel time/accessibility feedback loop between transportation and land-use models? If so, how many iterations are performed to achieve equilibrium? Is this feedback loop used in all land use modeling applications?
12. How is output of the land-use model translated into transportation model input?
13. Is any special projection used in transportation conformity?
14. Are land use scenarios developed for transportation options to respond to Clean Air Act (CAA) requirements?
15. Have any enhancements been made to land-use model to meet requirements of Clean Air Act?

Transportation Modeling

Regarding the transportation modeling, the following items were investigated.

1. Agency responsible for transportation modeling in the region
2. Transportation models - the current model
3. Transportation models - the future model if planned
4. Have any enhancements been made to transportation models to meet CAA requirements?

Air Quality/Transportation Conformity Modeling

Regarding the air quality/transportation conformity modeling, the following items were investigated.

1. Agency responsible for air quality modeling in the region.
2. Is the region designated a nonattainment area? If so, for which pollutant?
3. Air quality models - the current model
4. Air quality models - future model if planned

See the detailed result of the investigation in the appendix.

4. SYNTHESIS OF THE INVESTIGATION

From the investigation of MPOs in the previous section we can see that MPOs are modeling land-use transportation interaction by several similar approaches. The investigated MPOs are differentiated in the size of responsible area which has different growth rate. The control total used in the analysis either is given from higher organization or developed within the MPOs. Different land-use models are being implemented to forecast future land use in detailed geographical unit, which is an important input for transportation model.

Transportation models in the MPOs are all based on the conventional four-step model. Trip generation and distribution are usually done by a customized program. Mode choice is sometimes done by a separate program or by a commercial package. Assignment is done with off-the-shelf software package such as TRANPLAN or EMM2. Some of MPOs are joining or planning to join the development project of TRANSIM, which is a federal funded project for activity-based transportation modeling.

Since most of MPOs are now classified as serious nonattainment of air quality standard of specific items, they are under pressure to find way in order to pass the federal air quality conformity. Different ways of enhancements to their models of land-use, transportation, and air quality can be seen. The following subsections summarize some issues that are interesting and worthwhile to discuss.

4.1 How Land-Use is Treated in the Modeling

All of the MPOs investigated are using a model-based tool to model land use. Figure 1 illustrates this. 10 MPOs are presently using an explicit land-use model while the majority are using DRAM/EMPAL model. 7 MPOs are using their in-house developed rule based model. Nevertheless, it is worth mentioning that all of the MPOs investigated have no longer forecasted future land-use by the traditional way such as using the expert's opinion. It has now become a standard of the American planning organization to employ a quantitative and transparent mathematical model to make the forecast.

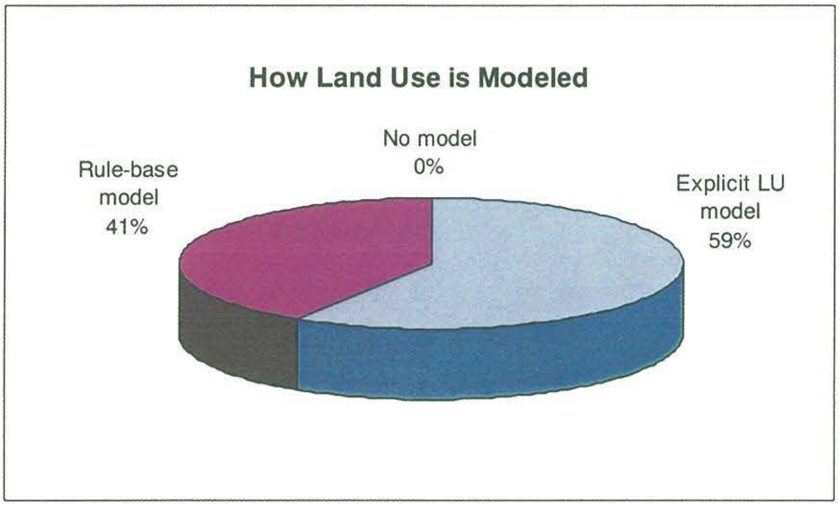

Figure 1 Treatment of land use in the planning

4.2 Trend of Land-Use Modeling

Among the MPOs that are using land-use model, they are using DRAM/EMPAL that has been a standard land-use model in the American organizations for many years, shown in Figure 2. Some other models are still minority in the US application.

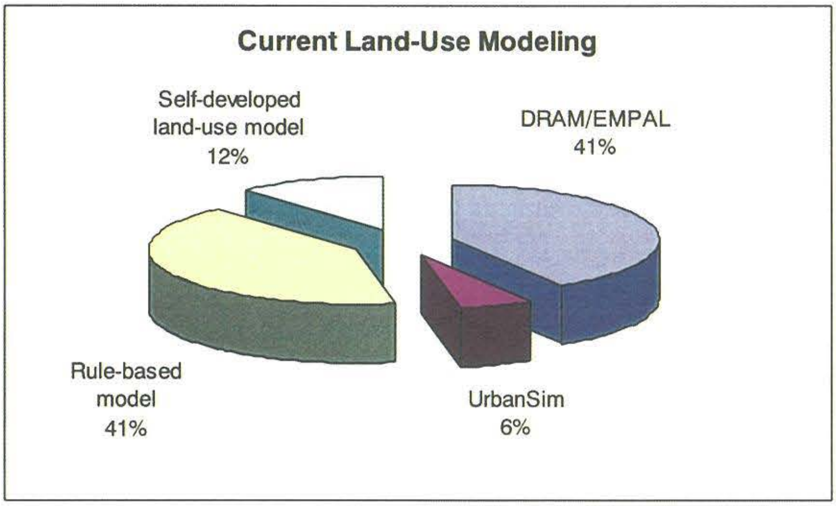

Figure 2 Current land-use modeling

It is interesting to foresee the future of land-use modeling in the US's MPOs. We believe that the MPOs that are using their in-house developed model will still continue using the same model. However, the models developed in the old days have many weakness points. DRAM/EMPAL does not have a representation of market; land price effects of changes in transportation services or policies cannot be estimated. Households and businesses compete for land, with the successful bidders determining the land use and location patterns that ultimately result from the market clearing process. Without a market representation, it is difficult to capture key aspects of the urban development process, or to test many public policies that impact prices of land or development.

There is, therefore, a trend that DRAM/EMPAL will no longer be a standard for land-use modeling in the United States. On the other hand, a sophisticated model will become more popular, shown in Figure 3. New model that can address more policy analyses will be continuously developed for each specific application of the metropolitan area. In this direction, UrbanSim is being implemented for more metropolitan areas such as Houston or Salt Lake City. The second stage model of Oregon is also being developed capturing more aspects of urban development. Sacramento is investigating and gradually collecting information for their new model, which can be immediately implemented when budget is allocated.

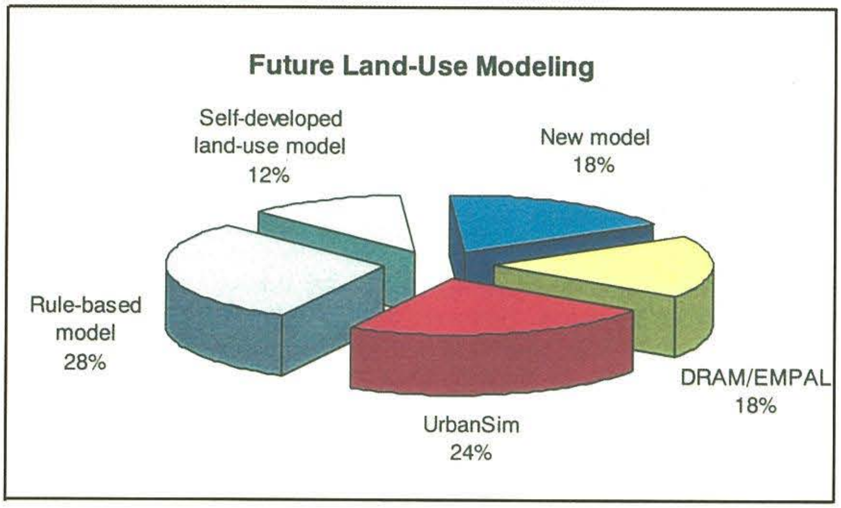

Figure 3 Future land-use modeling planned

4.3 Travel Time Feedback between Transportation and Land-Use Models

According to the investigation, it is known that some MPOs consider having feedback between land-use and transportation model within each time period. Three MPOs are implementing the feedback loop in their real modeling as shown in Figure 4.

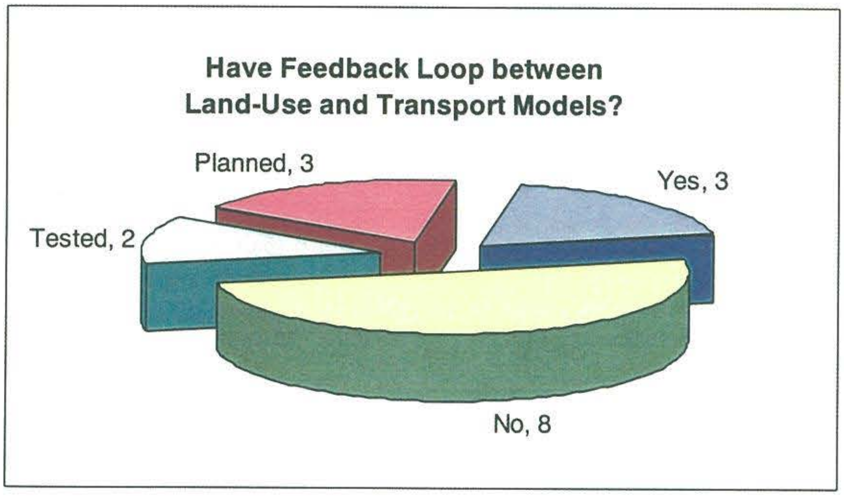

Figure 4 MPOs Implementing Land-Use Transportation Feedback Loops

In contrast to the normal structure of land-use/transportation interaction modeling in which land-use model and transportation model run consequentially, one following the other by quasi-dynamic, there is an intra-year feedback loop between the two models. Specifically, the result of transportation model is fed back to the land-use model and the whole system is run to an equilibrium solution. This procedure, which follows trip assignment, involves a particular form of averaging of the link volumes on the networks. This averaging can take several forms, but the method of successive average (MSA) has been shown to both reliable and computationally efficient. The equilibrium is reached when a pre-specified convergence criterion has met, or until a maximum permitted number of iterations have been reached. The typical DRAM/EMPAL application converges within three iterations, as the case of Dallas and Seattle investigated in this study. See TMIP (2001) for more detail. The issue of intra-time land-use transportation feedback loop has been discussed in the US MPOs. Although a few MPOs have implemented the feedback loop presently, three other MPOs have planned to implement it in their next model update. Moreover, two other MPOs have tested and are now having capability to implement it readily.

Horizon Year of the Forecast

Federal transportation planning rules require that MPOs uses at least a 20-year planning horizon in their transportation planning program. However, many MPOs exceed this in order to provide themselves adequate time to conduct periodic updates of their population and employment projections. That is, a 25-year forecast horizon allows MPO plans to stay within the federal requirements while providing the time needed to produce updates every five years. However, the choice of the horizon year also has important policy implications.

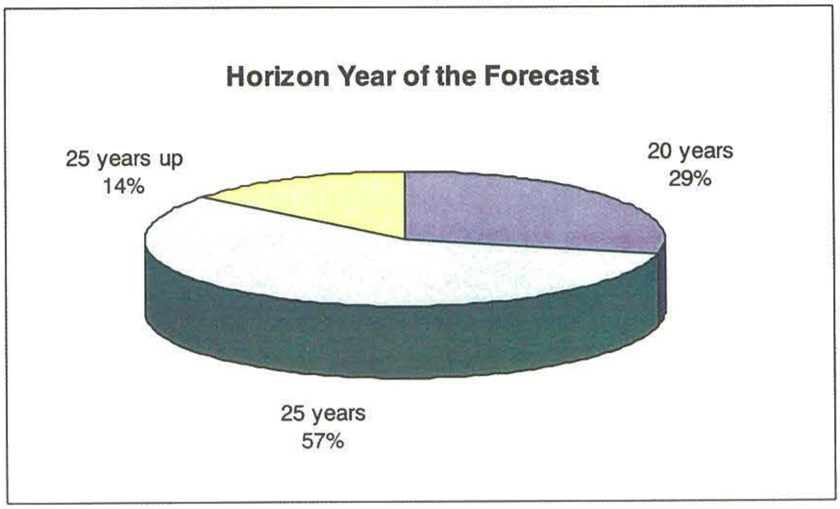

Figure 5 Horizon Year of the Forecast

Figure 5 shows the planning horizons used by the MPOs investigated. Most of MPOs use a 25-year horizon while some use longer horizon such as 30 or 50 years. This shows that MPOs spare some time for producing the next projections. However some MPOs are using a 20-year horizon such as Metro Portland and SANDAG.

In addition to its federal required transportation planning functions, Metro Portland also handles regional land use planning with the Oregon land use planning framework. The dual responsibilities constrain its ability to choose a longer horizon time. The 1995 amendment of Oregon Land-Use Law mandated that a 20-year supply of residential land be maintained. Because of the linkage between land use and transportation planning, it is not feasible for Metro to carry out transportation planning with the less restrictive 25-year horizon because it would conflict with the 20 year horizon under which it must forecast land-use.

For the case of SANDAG, it had faced a different set of conflict with its horizon year. The most recent forecasts indicate that San Diego cannot accommodate projected growth beyond the year 2015 (two years short of its twenty-year goal) because there is not enough land to meet the forecast level of development at the densities allowed by the local comprehensive plans (which SANDAG cannot alter). SANDAG has developed an interim solution to this problem by making limited changes to the allowable densities in some areas, but a long-term solution will need to be found. This illustrates how the choice of a horizon year can impact the ability to carry out the required forecast. A year that is too far out may lead to more growth than the constraints of local policy will accommodate.

5. USER-CUSTOMIZED MODELS

Almost none of the land-use models investigated, including the commonly used DRAM/EMPAL, have been implemented and used by Metropolitan Planning Organizations without substantial adaptation. These revisions or additions include programs to interface the models to the organization's existing data and travel models, and perhaps most frequently to disaggregate the land-use model to a level of zonal detail consistent with the transportation model.

5.1 Disaggregation Programs

Typically disaggregation programs are fairly simple in concept, and reflect the implementation of a set of decision rules for allocating population and employment from larger to smaller zones. They are generally based on available vacant land within the smaller zones, with varying degrees of prioritization of the zones for allocation of growth based on attractiveness factors such as accessibility. Where land use plans are available, these are sometimes used to constrain the allocations to the smaller zones to be consistent with adopted plans.

All MPOs using the DRAM/EMPAL models require the use of such disaggregation methods since the models are not typically implemented at the level of zonal detail required by the transportation models. Unfortunately, there is no standardization in the development and application of these tools, nor are they well documented. Based on our experience, none of the tools that fall into this category are calibrated systematically, nor are the predictions validated to assure that systematic biases are absent. It remains unclear how much error is introduced into the planning process using these disaggregation techniques, nor what the cumulative impact is of re-aggregating the travel model output into the less detailed zonal systems used in the land use models. Chapter 4 will present an algorithm for this disaggregation for the case of Atlanta MPO.

5.2 Adaptation of Existing Models

Some MPOs have modified existing models such as DRAM/EMPAL for their specific purpose. For example, the Puget Sound Regional Council developed a variation of the DRAM/EMPAL model that operates on a five year increment based on lagged levels of each variable, thus approximating a more dynamic behavior in the model application. Similarly, the San Diego Association of Governments has developed a hybrid approach that interfaces DRAM/EMPAL and PLUM, in order to refine the land use sensitivity and detail in the models.

5.3 In-House Model Development

As shown in Figure 2, some MPOs have technical staffs that have taken on the challenge of developing their own models. One of the most complete and well documented of these is the Association of Bay Area Government's POLIS model. Similarly, Portland METRO also has the in-house developed RELM (Real Estate Location Model) model.

In addition to the MPOs investigated in this study, there are many other in-house model development efforts that are not well known, and are rarely documented or publicized. This unfortunate reality means that many MPOs are investigating substantial quantities of time and resources to develop better or more tailored tools, without the benefit of knowing what has already been accomplished elsewhere. We have discovered that the works done in MPOs are mostly poorly documented so that the transferability of the knowledge is very slow.

6. CONCLUDING REMARKS

Under ISTEA, DOTs and MPOs need a new paradigm for evaluating the inter-relationships of land use and transportation. The hold paradigm assumed that land use planning drove transportation planning. The goal of transportation was to serve the planned land uses. Policy-oriented plan that assumed the build out of comprehensive plans were acceptable forecasts under this paradigm. Examining the land use impacts of transportation on a case-by-case basis in environmental impact studies was also standard practice.

The new paradigm requires thinking about the reciprocal connections between transportation and land use in all transportation planning. DOTs and MPOs must evaluate the land use impact of state and regional transportation plans. They must consider the consistency of transportation and land use plans. To do these tasks, they are applying the current analytical tools in new ways and developing more sophisticated method of analysis using the capacities of land-use models as well as other computerized tools such as GIS, which is now available to most planning organizations.

This chapter has presented the present situation of land-use modeling in many MPOs in the United States. It is clear that land-use model has been a standard tool in those MPOs for many years. The way they use those tools vary considerably depending on their purpose and limitation. MPOs that are using land-use model are continuously updating their model every time when new data is available. New tools such as new land-use models are being developed, which are becoming more sophisticated but is believed to represent the reality more accurately. The most important point of consideration to employ land-use model is then how MPO can use it most efficiently so that the most satisfied outcome can be expected from the modeling efforts. Many of them are further planning to implement a more sophisticated model such as UrbanSim. The next four chapters present some case studies of land-use modeling in many cities of the world. Two of these are cases of USA and the others are European cases.

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