Appendix B: Integrated Land Use and Transportation Models

This appendix contains a summary of issues related to the integration of land use and travel demand forecasting models. One of the goals of the LUTRAQ project has been to enhance the state of the art and state of the practice in integrated model development and application. The results of these efforts are summarized below.

Volume I of the LUTRAQ project, *Modeling Practices*, contains a review of the interactive transportation and land use model systems that were available at the time the report was written (October 1991). These systems were deemed to be the best available means to replicate the ways in which households and businesses make their decisions about where to locate, and the ways in which these decisions effect traffic congestion and automobile use.

In our review, we identified 14 commercially available land use model packages. We determined that three of these systems were the "best developed and potentially most useful packages" for understanding the relationship between suburban highway development, land use and travel behavior.

In the summary to that report we concluded that "travel demand forecasting in the United States has remained unchanged for too long. The tools in use today are not reliable for solving urban and regional transportation problems faced by metropolitan areas. The models are unable to simulate accurately... the responses of residents to the transportation choices and options they face everyday." (Vol. I, pg. 4).

Nearly five years later we can report that the challenge of enhancing the set of tools available to understand the relationships between transportation and land use in metropolitan areas has proven formidable. In the balance of this appendix we will briefly update the state of the practice in land use modeling. We will summarize the work undertaken by the LUTRAQ project in Portland, Oregon and the status of these efforts. Lastly we will identify other studies and ongoing efforts which continue to lay the ground work for the eventual development of a land use forecasting model well suited to the needs and constraints of practicing planners in the United States.

Update on the State of the Practice

In Volume I, we found that "less than a dozen agencies and regions have used land use modeling techniques to predict the locations of households and jobs. Among these few regions which have undertaken more sophisticated means of land use forecasting, however, only two have implemented fully the tools to predict ways in which congestion influences land use, while land use patterns simultaneously influence congestion" (pg. 3). Five years later, the list of metropolitan areas using land use modeling techniques has more than doubled. Experimentation with integrated transportation and land use models continues; however, there have been no major changes in the state of the art or the extent to which integrated modeling is practiced routinely by metropolitan planning organizations.

It is significant to note that several dozen metropolitan areas in the United States now are licensed users of DRAM/EMPAL, one of the three land use models we found best developed and potentially most useful in 1991. Many of these communities now use, or are in the process of calibrating, DRAM/EMPAL for the purpose of developing base case future land use forecasts. These forecasts are the bases for assignments of households and employees to travel demand forecasting models at the zonal level.

However, the introduction of formal land use models such as DRAM/EMPAL has proven to be challenging and problematic. (See “Other Studies,“ below.) This experience has paralleled the experience of the Portland metropolitan area, as described briefly in the section which follows. Thus, even as the licensing of land use models has grown significantly, their use for the kinds of policy analysis which is the subject of the LUTRAQ project remains quite limited.

In addition to the growing use of models like DRAM/EMPAL, a number of Metropolitan Planning Organizations have been experimenting with what might be called “sketch planning” models. These models are distinguished by the use of a relatively smaller number of zones than the number commonly found in models reviewed in Volume I. Further, the statistical foundation of the models is also more simplified. The models typically are easier to calibrate because the equations on which they are based use fewer variables. In exchange for the relative ease of computational skill and data collection, as well as lower costs, these models may sacrifice accuracy and reliability. However, all of the land use models currently in use in the United States, from the most sophisticated to the simplified, still appear to leave substantial uncertainty in their forecasts, requiring careful attention, the introduction of expert knowledge, and the expenditure of the significant amounts of time.

Even as several dozen metropolitan areas in the United States have been steadily working to increase the quality of their base case future forecasts, few have been working on the integration of transportation and land use models in a manner which allows for replicating the ways in which regions grow and evolve over time in response to transportation improvements. There has been continued, if not increased, interest in transportation and land use relationships, perhaps to some small extent the result of research and public education associated with this project. While some regions, including Portland, have experimented with integrated transportation and land use models, none of these experiments can be termed a complete success today. There is, in fact, a growing awareness of generic problems with the current generation of land use models used in the United States.[1]

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1. U.S. Department of Transportation, *Land Use Modeling,* conference proceedings (Washington, D.C., February 19-21, 1995).

Lastly it is important to note that, as model development and application work continues, important empirical research on transportation and land use relationships has also continued. Much of this work has focused on the ways in which land use influences travel behavior. Among the many research projects focusing on this subject is one sponsored by the Transit Cooperative Research Program on "Transit and Urban Form," from which several volumes will be published in 1996. However, research on the converse issue—ways in which transportation investment influence land use—has not produced results that are easily applied by practitioners.

Thus, in conclusion, the same challenge lies before the profession today as in 1991 —to develop analytic tools capable of measuring the interactions between transportation investments and regional growth and development. In the section that follows we will describe briefly the work that has been performed in this area by the LUTRAQ project.

Portland Modeling

In Volume 1, after reviewing the state of the art in integrated transportation and land use models, we reached the following conclusions:

1. "Of the model systems examined, ITLUP [DRAM/EMPAL], MEPLAN, and TOPAZ/TOPMET are the three best developed and potentially most useful packages.
2. Of these, we recommend the application of the ITLUP package for the LUTRAQ project. Because of the complexity of calibration, verification and application of any interactive land use model, the availability of Dr. Putman, the model developer, for this project is highly advantageous."

Since making that recommendation, the LUTRAQ team, including Dr. Putman and the Metro staff, has been involved in calibrating the DRAM/EMPAL model package and conducting several preliminary sensitively tests and simulations. As is characteristic of the model calibration of this software, the team consumed a significant amount of resources in data base development and in the calibration process. In addition to dealing with issues traditionally found in the calibration process (such as the accuracy and sufficiency of land use, employment and other data) the team identified several circumstances unique to Oregon which made calibration of the land use model somewhat more problematic. First, the presence of the urban growth boundary and of substantial federal land holdings in some of the more distant zones required attention to account for their effects on development or the absence of development at the zonal level. Second, the team found that the socioeconomic characteristics of the zones in the land use model were quite similar. In other words, the Portland metropolitan area exhibits relatively less economic segregation than is found in many other metropolitan areas. As a result, calibration of the residential allocation model, which is based on the discrete behavior of different income groups, was made more difficult. Third, the interval of time across which the model was calibrated was an unusual one for Oregon because the state experienced unusually high levels of economic growth. Thus, model calibrations based on residential and employment changes during these years may be considered somewhat atypical and unrepresentative for long-range forecasting purposes.[2]

Combined with these technical constraints, the LUTRAQ team's work on integrated modeling was slowed by the unusually heavy and pressing demands associated with the development of the Portland region's long-range transportation and land use planning process, Region 2040. This process, which uses the LUTRAQ paradigm of transit oriented development as the foundation for the development of a regional vision for metropolitan Portland, necessarily took precedence over refinements of the integrated transportation and land use model package. In addition to the practical constraints of budget limitations, these factors led to slow progress on calibrations and simulations for the LUTRAQ project. In light of these constraints, evolving project priorities, and the importance of bringing the project to closure, we have chosen to cease further work on this aspect of the project.

Other Studies

There were three important reasons for beginning work on the integration of DRAM/EMPAL into Portland's travel demand modeling system. First, it had been our desire to advance the state of the art in integrated modeling, and, ideally, to demonstrate the application of such models. Second, we sought to evaluate the interaction between transportation and land use—that is, the ways in which suburban freeways influence suburban land use patterns. Third, we wanted to evaluate the ways in which highway investments induce greater levels of automobile dependence—that is, decreased use of transit and increased automobile travel. In Oregon, increased auto travel has special significance in light of the state's established policy goal of reducing vehicle miles traveled per capita over the next 20 years.

Though LUTRAQ's work on integrated modeling did not further any of these objectives to a significant degree, other significant research efforts have been completed which further our knowledge of these subjects. In addition, several ongoing research projects hold promise for further progress in these important areas. The purpose of this section is to summarize briefly these relevant projects.

Regarding the integration of transportation and land use modeling, a major conference was convened in February, 1995, co-sponsored by the U.S. Department of Transportation, the U.S. Environmental Protection Agency, and the U.S. Department of Energy. As part of the conference, a select group of researchers and practitioners from U.S. DOT's travel model improvement program examined how well existing land use models and forecasting methods address the needs of practitioners and how they may be improved. They discussed potentially new land use modeling and forecasting techniques and suggested directions for future model development.

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2. For more information on DRAM/EMPAL calibration, see 1000 Friends of Oregon, *Making the Land Use, Transportation, Air Quality Connection*, Vol. 4, *Model Modifications* (Portland, Oregon, 1996), Ch. 2.

The summary of the conference proceedings includes the following conclusions:

- "Most existing models are not sufficiently sensitive to policy issues nor are they geared to understanding by non-modelers.
- "There is an absence of a clear describable basis of theory for current land use models, as well as an agreement on how they are to be used. Also missing are comprehensive guidelines on the use and application of existing models.
- "In general there is too little behavioral content to the existing land use models.
- "The existing models require a high level of effort and resources and substantial time for execution, thereby limiting their use and appropriate application.
- "Current modeling and analytical processes appear suitable for predicting urban sprawl, but are unable to assess controlled growth." (pgs. 2-3)

Attendees explored in specific detail ideas and suggestions for improvements to existing models and for the development of new land use models. Many of the concerns and issues identified at the workshop are consistent with previously published papers and articles on these subjects. Many of the limitations applicable to existing land use models were, in fact, problems faced by the LUTRAQ team in the course of the work in Portland.

We refer the reader to the proceedings from this conference in order to understand better the challenges and issues still facing practitioners interested in land use modeling and its integration with transportation and environmental model systems.

In addition to these conference proceedings, a 1995 Transportation Research Board Special Report titled *Expanding Metropolitan Highways: Implications for Air Quality and Energy Use* is also relevant here.[3] The purpose of the report was "to review the current state of knowledge, evaluate the scientific evidence, and narrow the areas of the agreement about the impacts of highway capacity additions on traffic flow characteristics, travel demand, land use, vehicle emissions, air quality, and energy use." (pg. vi) The report's authors specifically examined the impacts of increases in highway capacity on land use and urban form, and summarized their findings as follows:

- "Additions to highway capacity that reduce the cost of travel have a decentralizing effect on urban development. This effect is most pronounced when the added capacity provided improved access to developable land in outlying areas.
- "Provision of highways, combined with transportation and land use policies that have fostered motor vehicle travel and low density development, has supported the decentralization of metropolitan areas in the United States. Many other factors have influenced the process as well...
- "Early major highway capacity expansions have major impacts on land

3. Transportation Research Board, *Expanding Metropolitan Highways: Implications for Air Quality and Energy Use*, Special Report 245 (Washington, D.C.: National Academy Press, 1995).

use and urban form in metropolitan areas... In general, currently planned expansions of existing highway networks in built up metropolitan areas are not likely to result in major structural changes in metropolitan development patterns...

- "Planned major highway capacity expansions in relatively undeveloped areas, such as outer beltways at the urban fringe, that significantly reduce travel times and improve accessibility to developable land will influence development patterns in these corridors.
- "State of the art operational land use models, assuming current land use policies and controls, predict small changes (i.e., plus or minus only a few percentage points) in regionwide locations of employment and households in built up metropolitan areas over a 20-year forecast period, even from systemwide changes of travel time of as much as 20 percent.
- "State of the art operational land use models can provide a sense of the likely magnitude of locational changes resulting from expansions in highway systems apply. However these models cannot accurately estimate the effects of relatively small changes to highway networks." (pgs. 222-223)

These findings, derived from a review of the best available empirical and modeled data, serve as one important summary in the state of knowledge on the interaction between transportation and land development in metropolitan areas. In a minority statement, one of the authors noted, "The committee report is correct in identifying the need to improve our analysis tools, but it errors by asserting that we cannot adapt these tools to meet current regulatory requirements without substantial delay. The problem is not a lack of good science to support analysis, but institutional resistance to the use of good science..." (pg. 354). The author notes that even as the current generation of forecasting models, including land use models, are being criticized as insufficiently reliable, the results of their application in simulation situations are being quoted and used as the basis for policy recommendations regarding future transportation policies and priorities.

Thus, the TRB Special Report appears to be the latest but by no means the last word on the set of issues and concerns which have been at the heart of the LUTRAQ project.

Regarding the effects of highway construction on automobile dependence, researchers in the United Kingdom issued in December, 1994 a closely reasoned report, *Trunk Roads and the Generation of Traffic*.[4] The issue of induced travel is, at its core, nearly identical to the issues at the core of the TRB Special Report issued in the United States. The authors note (pg. 31) that,

> "For both statistical and conceptual reasons it is inherently difficult to prove definitively that the phenomena of induced and suppressed traffic exist and certainly not simply by analyzing traffic counts and surveys. Therefore it is necessary to refer to a wide range of direct and indirect

4. Standing Advisory Committee on Trunk Road Assessment, *Trunk Roads and the Generation of Traffic* (London: HMSO, 1994).

> evidence to come to a view about the balance of the likelihood of the existence and scale of the phenomena."

Toward this end the authors reviewed a wide variety of research, principally but not exclusively from the United Kingdom. Reviewing data from this point of view, the authors found particularly compelling the body of evidence on the general relationship between travel times and travel demand. They note,

> "A simplified calculation suggests that about half the time saved through speed increases might be used [by motorists] for additional travel. We interpret this as a short term effect. The long-term effect is likely to be greater, with a higher proportion (perhaps all) of time saved being used for further travel." (pg. 47)

In their conclusions they note (pg. 166) "that, over a long period, traffic growth rates have been slowest where congestion is worst and fastest where there is still spare capacity or where new capacity is provided. Association does not prove causation, but the evidence is at least consistent with the possibility that new capacity, by raising network quality, will indeed induce some vehicle kilometers which would not otherwise take place." They conclude (pg. 170) "that induced traffic is of greatest importance in the following circumstances:

- where the network is operating or is expected to operate close to capacity;
- where the elasticity of demand with expected travel cost is high;
- where the implementation of a scheme causes large changes in travel costs."

In general, the tenor of the U.K. report is that increases to highway capacity do influence automobile use, while U.S. researchers emphasize, instead, the likely sources for errors in existing formal model structures, and in an important set of "concluding observations" (pgs. 230-233) the need to "look for solutions that reconcile air quality with economic goals in metropolitan areas" (pg. 231). These complementary perspectives once again stake out the terms of a debate which is likely to continue on both the magnitude and significance of transportation/land use relationships.

Another important research project which may advance both the state of knowledge and the state of the practice is being sponsored by the National Cooperative Highway Program in the United States. NCHRP Project 8-32(3), *Integration of Land Use Planning Data with Multimodal Transportation Planning* will produce in draft form in 1996 a synthesis of knowledge of transportation/land use relationships and, in 1997, a plan of work for the development of a land use model platform which addresses many of the concerns identified by attendees at the Travel Model Improvement Program Conference in 1995. Information on this project can be obtained from the Transportation Research Board. In addition, the Transit Cooperative Research Program (TCRP) will sponsor in 1996 Project H-12, "Integrated Urban Models for Simulation of Transit and Land Use Policies." In the 1996 TCRP Program announcement this project is described in the following terms:

> "Research is needed to ensure that the next generation of travel demand models simulates land use and transportation interactions more accurately and, specifically, the interaction between public transit and land use."

In conclusion, the limitations reached by the LUTRAQ team in advancing the state of the practice in the integration of transportation and land use models give evidence of the complexity of the challenge facing planners and citizens seeking answers to the questions posed in the LUTRAQ study. The magnitude of effort being devoted to addressing transportation and land use issues today gives hope that steady progress will be made in developing the next generation of tools for analyzing transportation/land use interactions.