

UC Berkeley

Proceedings

Title

Transportation Models In the Policy-Making Process: Uses, Misuses, And Lessons For The Future

Permalink

<https://escholarship.org/uc/item/47h925rc>

Authors

Brinkman, Anthony
Goldman, Todd

Publication Date

1998-12-01

Institute of Transportation Studies
University of California at Berkeley

**Transportation Models In the Policy-Making Process:
Uses, Misuses, And Lessons For The Future**

**Anthony Brinkman,
Todd Goldman**

RESEARCH REPORT
UCB-ITS-P-98-2

December 1998
ISSN 0192 4117

Transportation Models In the Policy-Making Process:

Uses, Misuses, and Lessons for the Future

Proceedings from a symposium on
the problems of transportation analysis and modeling
in the world of politics.

In memory of Greig Harvey

**March 4-6, 1998
Asilomar Conference Center
Pacific Grove, California**

Sponsors: University of California Transportation Center
The Energy Foundation
Federal Highway Administration
Metropolitan Transportation Commission
Southern California Association of Governments
U.S. Environmental Protection Agency

Symposium Planning Committee

Martin Wachs, University of California at Berkeley – Co-chair

Karen Frick, Metropolitan Transportation Commission – Co-chair

Mark Brucker, U.S. Environmental Protection Agency

Michael Cameron, Environmental Defense Fund

Elizabeth Deakin, University of California at Berkeley

Geoff Gosling, University of California at Berkeley

Linda Howe, University of California at Berkeley

Chuck Purvis, Metropolitan Transportation Commission

Alex Skabardonis, University of California at Berkeley

Dan Sperling, University of California at Davis

Ann Stevens, Consultant

Conference planning services provided by the Institute of Transportation Studies Technology Transfer Program, University of California at Berkeley

Proceedings written by P. Anthony Brinkman and Todd Goldman; edited by Todd Goldman

Table of Contents

<i>Panel 1: The Promise and Limitations of Transportation Modeling and Analysis</i>	3
The Functions of Models and Analysis in the Policy Process – Martin Wachs	
What Do Societal Changes Mean for Transportation Planning? – Genevieve Giuliano	
A Response to Martin Wachs and Genevieve Giuliano – Lawrence Dahms	
<i>Forum: Developing Modeling Guidance for Transportation Conformity</i>	9
<i>Panel 2: Integrating Transportation, Land Use, and Environmental Analysis</i>	13
Introduction – Mark Brucker and Ann Stevens	
Case Study in Advocacy Modeling: Portland – Keith Lawton and Keith Bartholomew	
Modeling Needs in the New York Metropolitan Area – Therese Langer and Jeffrey Zupan	
Perspectives – Frank Koppelman and Michael Replogle	
<i>Panel 3: Analysis of Intercity Transportation Problems</i>	22
Intercity Demand Models and the Economic Effects of Deregulation – Cliff Winston	
Modeling the Demand for High-Speed Intercity Rail Services – Daniel Brand	
State of the Art of Airport Choice and Ground Access Models – Geoffrey Gosling	
Perspective – Edward Jordan	
<i>Panel 4: The Role of Analysis in Transportation Pricing and Equity Decisions</i>	28
Introduction – Michael Cameron	
The I-15 HOT Lanes in San Diego – John Duve	
Congestion Pricing on the San Francisco Bay Bridge – Steve Heminger	
Dichotomy Between Efficiency and Equity in Public Transportation – Brian Taylor	
Political Issues in Congestion Pricing – Fred Salvucci	
<i>Presentation & Forum: A New Paradigm for Modeling</i> – Marvin Manheim.....	36
<i>Panel 5: Future Innovations in Transportation Analysis</i>	41
Introduction – Chuck Purvis	
Behavioral Realism in Urban Transportation Planning Models – Moshe Ben-Akiva	
Large Scale Systems Modeling – Mary Lynn Tischer	
Future Issues in Air Quality and Mobility – Arnold Sherwood	
<i>Conclusions: Interpretations and Lessons for the Future</i>	46
Summing Up What Has Been Said – Elizabeth Deakin	
Some Common Threads – Michael Meyer	
Final Comment – Fred Ducca	
<i>Speaker Biographies</i>	50
<i>Participant Roster</i>	54
<i>In Memoriam: Greig Harvey</i>	55
<i>Bibliography</i>	57
<i>Memorial Fund</i>	59

Panel 1

The promise and limitations of transportation modeling and analysis

This session set the stage for the conference by examining some of the overarching issues in transportation modeling. Martin Wachs spoke about the promise and limitation of models from an ethical frame of reference. Genevieve Giuliano followed with an examination of how some of the changes underway in society may limit the ability to produce useful transportation forecasts. Finally, Larry Dahms commented from the perspective of an agency that operates within the policy-making process.

The Functions of Models and Analysis in the Policy Process

Martin Wachs, University of California at Berkeley

Models play both practical and intellectual roles. As practical instruments, they provide information for decision makers. Modeling and analysis, while not always producing reliable results or trustworthy information, is the best method available to test the likely implications of alternative courses of action in real socioeconomic systems. Consequently, these techniques have attained a central place in the policy making process. In many cases, models are applied in situations that have enormous political consequences and the information they provide is often required by law as well as by custom despite its shortcomings. However, this prominent place afforded modeling is by no means necessarily a privileged place. In a democracy, the right to make decisions is reserved to deliberative processes and representative bodies. Required only is that modeling and analysis is done and considered in policymaking. The function of analysts is to enrich and enliven those processes.

Another practical role models play is that they provide means for modelers and consultants to earn a living. Modeling is an expensive enterprise. Yet because it is often mandated, those with the expertise needed for this work are in the enviable position of potentially garnering significant economic rewards. This fact, inherently, is a force for conservatism and slows innovation or intellectual experimentation. As long as a consultant can make more money selling an existing model than developing one that is more theoretically sound and potentially better able to predict future outcomes, there is little motivation to advance the art and science of modeling practice. In this environment, it takes special people to reach beyond the minimum requirements and assert leadership.

Models play an intellectual role by encapsulating analysts' understanding of the complex systems they model. Analysts think of problems and processes in terms of the structure of their models. Our sense of intellectual community, our notion that we are a profession, our identities as participants in an important endeavor are shaped by our models which represent our way of understanding how the world functions. For example, the federal government is devising an entirely new approach to modeling that has come to be known as TRANSIMS. Beyond the fact that it drew scarce resources that otherwise might have been used elsewhere, the modeling community was un-supportive of this program because it threatened the hegemony of certain ideas to which many modelers are wed, not because it might yield inferior forecasts or produce less practical results for decision makers. Models also symbolize paradigms and as such take on some of the trappings of ritual, rite and cultural icon. The succession of model improvements over the years is the way society learns collectively how its social, economic and decision making systems actually work. From this perspective, modeling and analysis appear more important than simply the forecasts they help to produce.

The technical limits of models and decisions of the analysts that manipulate them and interpret their outputs can affect how models and analysis are used in policy making. A recent Transporta-

tion Research Board (TRB) investigation demonstrated that compounding in the modeling process can sometime produce errors that are often larger than the differences between the performance of the alternatives evaluated. Successful litigation in California by environmental groups served to underscore the need for models to be more reflective of the actual understandings of the physical relationships and processes they represent. The lawsuit brought against MTC reminds us that land use and urban development models are an enormously weak link in the ability to use models effectively in policy analysis. Unfortunately, the trend in the profession is to refine models in areas where there are already strengths while continuing to ignore the gaping weaknesses. The influence of the modeling profession in the policy making process will decline if the technical limits of models cannot be overcome.

Beyond the technical limits of forecasting, models and modelers can, and often are, corrupted or compromised in practice by political pressures. Decision makers engaged in high stakes competition for federal grants and/or political commitments want the models to support the projects they advocate. Modelers in turn are compelled to come up with the “right answer” by producing analyses of dubious quality. Typically, this involves adopting assumptions in the models that are not supported by the data or are even intuitively correct. In the end, the technical limits of the same models used vociferously to justify earlier decisions are blamed along with the modelers for their failure to produce accurate forecasts. The examples are legion. The issue, however, is raised here not to point fingers but rather to raise challenges for the profession.

If models played only the practical role described earlier, the misuse of models would be merely damaging and disappointing. The deep pain felt in the analytical community, however, stems from the intellectual role models assume. Since models represent the world the way we understand it to be organized and to function, the casual use of models is a corruption of our intellectual capital, a negation of the significance of our knowledge in the decision making process and a personal affront. Changing the numbers for political purposes also denigrate our concept of ourselves and says that we live in a world in which knowledge and understanding consist of whatever can be bought and that they are of less important and secondary to financial rewards and political loyalty.

Are modelers culpable? To some extent, the issue is really beyond us. However, in many respects modelers are also to blame for the current state of affairs. In addition to a demonstrated venality, modelers make the mistake of separating themselves from value-laden questions which invites others to take their work and use it for their own purposes without expecting even an objection from the authors. To be effective, analysts who use models have to be passionate advocates for what they believe. Modelers who fail to communicate the results of their analyses and the meaning of the model structures to decision makers also invite misuse of their work. If we remain aloof, if we believe that the technical inner-workings of our models are too complex to communicate to elected officials or political appointees, if we expect others to trust us because we are the technical experts and they need not understand our expertise, aren't we also inviting them to treat our expertise as a commodity to be bought and sold and used instrumentally for whatever purpose seems most appropriate to them at the time? Modelers and analysts are not without the means to make a difference.

Greig Harvey, in whose memory we are gathered here to honor, was unique in the way that he took the time to stand back from the technical details of the models and contemplate the larger social and symbolic meanings of the modeler's undertakings. Greig understood and demonstrated that advancing the state of the art and practice in modeling was critical to the credibility of the profession, that communication was central to modeling, that models encapsulated society's understanding of the systems that they represented and, most importantly, that capitulation to simple crass political priorities was not an inevitable outcome of analysis and modeling. By reaffirming the principles that Greig brought to his work, excellence and clarity in the pursuit of honest participatory decision making is something to which every modeler can contribute.

What Do Societal Changes Mean for Transportation Planning?

Genevieve Giuliano, University of Southern California

Good planning requires good predictions and good predictions require good models. But what is a good model? Good models are internally consistent and accurately replicate the behavior patterns of households and firms. Unfortunately, transportation models used in planning practice today are not good models. They are not internally consistent and they have no basis in behavioral theory. Good predictions also require a relatively stable world absent of large exogenous shocks and without great changes in the behavioral relationships on which models are built. In recent history these criteria too have not been met, making the transportation planner's task today increasingly formidable.

It is useful, therefore, to examine some of the major structural changes and exogenous shocks that may account for some of the great past errors in prediction. Three structural changes that occurred at a rate and extent far beyond what was predicted have produced a plethora of travel implications:

- *Suburbanization of population and jobs* has led to a decline in commutes to central cities, an increase in cross-commuting, longer distance commutes of shorter duration, and mode shifts away from transit to single occupant vehicles.
- *Female labor force participation* exceeded expectations, increasing female VMT, automobile use and trip chaining.
- *Changes in household characteristics* – including declines in household size and the share of households with traditional family structures – brought increases in total trips, automobile use and non-work travel.

Important exogenous events that affected travel demand included:

- *The declining real price of fuel*, coupled with rising real household income, led to the resurgence of the gas guzzler in the form of sports utility vehicles.
- *The economic recession of the early 1990s* brought a decline in congestion and VMT in many metropolitan areas.
- *The surge in foreign immigration*, particularly to the southwestern U.S., brought low-income immigrants who increased demand for transit in central cities. Planning to meet this new transit demand is complicated by its transitory nature: the new transit riders make the transition to a privately owned vehicle after only a small rise in income.

So what lies ahead? The basic trends of population and employment decentralization continue unabated and now are widely detected outside of the United States. Trends in vehicle tenure and use are also global. Worldwide, automobile ownership, mode share and VMT are increasing.

The factors underlying these trends are numerous:

- *Economic productivity gains* are bringing higher real household incomes. This allows more discretionary consumption on items such as housing and travel, and increases the value of time resulting in an increased demand for higher quality (i.e. faster) transport.
- *Emerging information technology and the changing economic structure* have wide-ranging implications. Advances in communications and information technology have changed how goods and services are produced. Flexible production, vertical disintegration, just-in-time in-

ventory, and distributed systems require smaller and more frequent shipments. While agglomeration economies may exist, these will lead to increases in the size of metropolitan regions, but not necessarily clustering or centralization.

- *The changing world of work* is a result of the trends mentioned above. The demands of a flexible production regime for a flexible workforce have resulted in rising self-employment, job turnover rates, and temporary, contract, part-time and home-based work. But this flexibility is demanded by labor as well as by firms. These changes in the work environment stemming from information technology and the changing economic structure will have large impacts in terms of travel.
- *Globalization*, including the global scale of economic competition, as well as the rise in multinational firms, is bringing a rise in global flows of goods and information. It may also limit the power of governments in some policy areas, including transportation.

These current trends have important location and travel implications:

- Demand for high quality intra- and inter-metropolitan travel will continue to increase.
- Overall demand for travel will increase, due to longer commutes, and more work- and non-work-related travel
- Overall demand for goods movement will increase.
- Decentralization of population and jobs will continue, but to what extent remains unclear.
- Dispersion of activities will predominate over concentration.
- Amenities will play a greater role in location decision making for both households and firms because dispersed land use patterns decrease the relative differences among locations.

How will these emerging realities affect transportation modeling? Quite simply, accurate prediction will be increasingly difficult. This is likely because the rate of change in factors that affect location and travel is increasing, households and firms are increasingly footloose and the role of unique factors in location choice is increasing which implies random elements will have greater effects. But since transportation policy decisions must still be made in the future, the need of modelers for better tools will not diminish. In a rapidly changing world, models appropriate for scenario evaluation may have great value. Analysts must understand the limits of policy intervention, even when advocacy groups do not like the implications.

Greig Harvey was committed to moving forward the state of the art in planning practice. He was selfless in his efforts to assist states and regions in using better data and better models, and he understood, far more than I, the many pitfalls and problems practitioners face. It is my hope that this symposium will carry his work forward, both by prompting the research community to pick up where he left off and by prompting decision makers to continue to demand better analytical tools from us.

A Response to Martin Wachs and Genevieve Giuliano *Lawrence Dahms, Metropolitan Transportation Commission*

Professors Giuliano and Wachs appear to disagree: Giuliano asserts transportation modeling cannot keep pace with the dynamic changes we see, while Wachs is more hopeful, visualizing models as ways of describing our understandings of complex processes.

On the other hand, they do agree on several points. First, finding tools to bridge the gap between analysis and policy is a common professional objective. Second, Greig Harvey stood out because of his skill at, and commitment to, honing these tools. Finally, there are well-defined circumstances where modeling is relevant and many others where too much is expected of models and as a result they are misused or misunderstood.

Modelers were the founders of the Metropolitan Transportation Commission (MTC). As an institution, MTC has assumed the role of a bridge between professionals and politicians. Its challenge was, and remains, to inform the political process as best as possible. This has, on occasion, required MTC to reach outside the organization for modeling advice. In many instances, it turned to Greig Harvey for that assistance. Examples included Harvey's work as key advisor on the airport access estimates related to the billion-dollar BART-SFO project, and on several stages of air quality analysis for which MTC has been responsible. Harvey brought a common sense approach to these endeavors, the virtue of which is not lost on participants and observers of the policy making process.

Martin Wachs lamented about the "tragedy of the disconnect between policy makers and modelers." There are three reasons for the incongruence:

- *Limitations of the models themselves*, due to technical limitations, limiting assumptions, etc.
- *Mismatches between the answers the models provide and what is politically acceptable* (e.g. pricing as an alternative to new construction).
- *Mismatches between where the decision is made versus where the analysis is conducted* (e.g. the relevancy of air quality conformity analysis performed by MPOs is questionable when it is the decisions that were made in Congress and in boardrooms of the major automobile manufacturers have led to at least 95% of the mobile source contribution to cleaner air.

Only in Washington, D.C., and to a lesser extent in Sacramento, can policies be adopted that are sufficient enough to bring economic development into harmony with the environment. Our models break down on this third gap between analysis and policy, when the modeler is asked to discover and act on matters almost completely beyond the range of the parallel decisions that local and regional politicians can make.

Bill Hein, the Deputy Director of MTC, said about Greig Harvey, "He enjoyed the give and take of the debate—into the late hours—and brought a certain joy and enthusiasm to the table that elbowed out the distrust between analysts and those trying to form transportation policies." Let us carry on this fine tradition.

Discussion

The following themes were raised in the discussion that followed:

- *Importance of qualitative research.* Models can't explain the public's preference for sport utility vehicles or politicians' support for projects not substantiated by technical analysis. These phenomena are deeply rooted in the metaphors individuals rely upon to understand the world and their place in it. Since these are revealed through discourse, good policy making requires more qualitative forms of analysis. There is a need to move toward discourse in the ways professionals formulate the problems and in the provision of inputs for the things considered when modeling.
- *Don't blame the models when their purposes are suddenly redefined.* Perhaps our old four-step models are fine as they are, and the problem lies in the questions that are being posed to them. Historically, these models were designed to examine changes in infrastructure. Since the passage of the Clean Air Act Amendments and the Intermodal Surface Transportation Efficiency Act, they have been used to explain how systems operate. This requires much more sensitivity than the models currently possess. Professionals must also address emerging questions that have yet to catch their attention like sustainable development, environmental justice and the equitable provision of transportation resources, but we shouldn't expect the same models to be able to answer these questions, either.
- *Poor communication by modeling professionals* to policy-makers and the public is a fourth item that could be added to Dahms' reasons for the wide gap between modelers and policy makers.
- *Importance of federal money in policy making.* Federal funds play a significant role in biasing local and state decisions, especially on highway projects. Interestingly, the devolution debate taking place in Washington has actually been implemented in California with passage of Senate Bill (S.B.) 45. In California, the combination of S.B. 45 and ISTEA allows local and regional entities considerable flexibility in programming transportation funds. This development has the potential to reduce the competition between regions that often invites the misuse of models.
- *Advocacy modeling?* One participant questioned Wachs' assertion that modelers must be passionate advocates for what their models convince them is true, explaining that advocates often are less credible to the public than those who appear as dispassionate objective analysts. Wachs answered that many scholars have concluded that there is no such thing as a neutral analyses. Advocacy is the only honest way to present analysis. Professionals must concede that they bring values to their work. Dialogue is needed to acknowledge all modeling is in some ways subjective.
- *Modeling must be kept in place.* To the degree that modelers succeed in capturing the central decision making process, it places pressure on those at the local level to play all of the modeling games we criticize. An example is provided by the contrast between the Federal Transit Administration (which places inappropriate emphasis on models and hence creates an incentive for gaming the results), and the Federal Highway Administration (which more suitably uses technical analysis as a point of discussion rather than a definitive decision-maker).
- *Planning needs to be more strategic.* Policy analysis is too often treated as an engineering exercise. This is inappropriate because conditions change too rapidly. Planning should be approached more strategically and evaluated post-event. More careful selection of clients by professionals is perhaps the only way to advance the state of the profession.

Forum

Developing DOT/EPA modeling guidance for transportation conformity

The Conformity Rule applies to regions with an urbanized population of more than 200,000 people and air quality problems “serious” or worse. It requires consistency between transportation and air quality plans, as well as their expected outcomes. The original rule was promulgated by the Environmental Protection Agency and the Department of Transportation in November 1993, and a streamlined version was issued in August 1997.

The revised rule dropped some modeling requirements that proved difficult to implement, and promised to follow up with modeling guidance. EPA and DOT have held workshops in ten regions, using practitioners in ad-hoc discussion groups to identify issues needing clarification and to develop guidance. It is hoped that this will be an ongoing process.

Issues that EPA and DOT have committed to covering in their guidance to MPOs include:

- Validation for more than just one base year
- Reasonableness checks
- Modeling inputs and assumptions
- Feedback requirements, and its relationship to calibration
- Definition of "realistic free flow speeds"
- Use of peak hour vs. daily average speeds

The purpose of this forum was to identify other issues that EPA and DOT should include in their conformity guidance. However, the debate addressed a wider range of issues, including the merits of the Conformity Rule itself. Discussion was moderated by Lucy Garliauskas for the Federal Highway Administration and Kathryn Sergeant of the U.S. Environmental Protection Agency, and centered around the following issues:

Specific Topics Needing More Detailed Guidance

- *Land Use.* More specific guidance is needed on both land use provisions of the Conformity Rule. The rule contains two provisions relating to land use: one that states that assumptions must be documented and based on the best available information; and another that requires that land use scenarios be reasonable and consistent with their associated transportation system alternatives. In the past, DOT has suggested that more detailed guidance on these provisions would be forthcoming, but now it looks like this will not happen.
- *Peak Spreading.* It is widely accepted that people respond to congestion and the cost of travel. Yet widespread use of 24-hour travel models and crude peak-hour analyses limits their capacity to evaluate transit-oriented development vs. sprawl scenarios. Peaking tends to be higher in homogenous settings than heterogenous ones.
- *Drive Cycles.* Models should differentiate between hot & cold starts, in order to better reflect the benefits of trip chaining.
- *Mode Choice.* Models of mode choice should include land use variables.
- *Emissions Budgets.* Guidance is needed for how to establish emissions budgets for “outer” years (not specified by state air quality implementation plans).

- *Demographic Differentiation.* Travel behavior should be differentiated by income levels. Also, the economic well-being of different income groups don't rise in synch; lower income groups are falling slightly. This has implications for the analysis of future welfare-to-work needs.
- *Vehicle Ownership & Choice.* Land use variables should be included in vehicle ownership models. Also, very good models exist for predicting what vehicles are owned by individuals of different income levels. This can help improve estimates of energy use and emissions levels, so MPOs should be encouraged to try using them.
- *Documentation of Assumptions and Uncertainties.* It was widely agreed that the models used in conformity analysis create large cumulative uncertainties and systematic errors that significantly reduce the significance of their results. Despite these problems, uncertainties and errors are rarely traced and reported along with modeling results. Modelers should be given more specific guidance on how they should document and explain their assumptions, and track and report their uncertainties.
- *Reasonableness.* Assumptions and results must be reasonable. Federal guidance should recommend that modelers base their assumptions on broadly recognized data sources wherever possible (e.g. federal gasoline price forecasts), or otherwise provide some justification for why their projections differ. It should also recommend a series of specific reasonableness checks that modelers could use to detect nonsensical results.
- *Alternatives Analysis.* In “off years” (when conformity analysis is not required), MPOs should be encouraged to conduct analyses of alternative policy/investment scenarios.

The Conformity Rule's Impact

There was considerable discussion about whether the Conformity Rule could actually be expected to improve air quality and the transportation planning process. Several participants expressed the view that conformity analysis was too weak a lever to actually influence transportation decisions, and that it would generally bend to the will of transportation decision-makers. They voiced concerns that conformity had been detrimental to the overall planning climate and called for it to be replaced by alternative fora and processes that would be more likely to produce real results. Their arguments included:

- *Disincentives to innovate.* The analytical burdens imposed by conformity drain resources from modelers' abilities to improve networks and models. Also, since updated models would likely show new road capacity worsening air quality, conformity provides a disincentive to improving these models. Furthermore, the rule may discourage projects that cut emissions in the long run but increase them in the short run.
- *Impediments to debate.* The regulatory climate in which conformity analysis occurs has reduced it to a tool that enables environmental groups to sue if MPOs are not following federal procedures. The focus on fulfillment of legal mandates closes opportunities to do other more creative or inclusive forms of planning. The complexity of conformity analysis itself limits opportunities for public dialogue and drives people away.
- *Distortions of results.* The huge political stakes create tremendous pressures on modelers to distort their results. Much of the modeling used in conformity analysis is meaningless, as modelers will do what is necessary to get the results needed to justify political decisions.
- *Misplaced burdens.* Conformity analysis might influence decisions in regions with marginal air quality problems and a willingness to innovate, but is unlikely to become an issue in areas

with more serious problems, or where efforts to improve air quality are lacking. In this sense, it burdens the regions that are already on the right track.

In light of these difficulties, some argued, strengthening the Conformity Rule's modeling requirements in the ways suggested above could drain MPO resources further, without necessarily improving the ultimate quality of the analysis. The costs and benefits of any additional requirements should be weighed carefully. We shouldn't make assumptions that better models will overcome political dysfunction; instead we need planning processes that create a learning process over time.

But other participants disagreed, arguing that the most significant impacts of the Conformity Rule are yet to be seen. They argued that the rule itself should be seen as a learning process, and that it should not be judged a failure based upon the earliest years of its implementation. Their arguments for strengthening the rule and forthcoming guidance notes the following issues:

- *Guidance is non-binding.* The forthcoming guidance will be non-binding, and is intended to point the way toward good practice. Rather than increasing regulatory burden, it may actually ease some of the pressure on modelers by reducing the threat of spurious litigation.
- *Improvements are not difficult.* Many of the needed modeling improvements identified by the group don't necessarily involve advanced practice, and are well within the existing capacity of MPOs. They simply require that modelers adopt scientific norms for documentation and justification of assumptions, and tracking and reporting of uncertainties and error. Others could be achieved through federal outreach.
- *Emphasis is shifting.* Early implementation of conformity placed undue emphasis on the build/no-build test, which created tremendous opportunities for gaming with no incentive to improve models. Recent revisions to the rule will shift the emphasis to emissions forecasts vs. emissions budgets. This will focus more attention to the policy contexts of investment choices, and create incentives to improve models to that they can respond to policy variables.
- *Burdens are voluntary.* The difficulty in achieving emissions budgets through the conformity process is determined by *states*, not the federal government. States have great flexibility in determining how they will meet air quality mandates; in the transportation sector they can rely on reformulated gas, emissions controls, etc. If they choose to set over-ambitious targets for reducing VMT, the Conformity Rule should not be blamed.
- *Funding is provided.* The conformity process is not an unfunded mandate. ISTEA increased planning funds and provided flexible money. States have not chosen to flex these funds.
- *Change is occurring.* We already have one success story of how conformity has changed the public policy process where there has been historical resistance to change, and perhaps have another in the works. In response to pressure environmentalists were able to apply through conformity, Denver improved their model and found that transit-oriented development and other policies could help them with congestion and air quality. In Atlanta, the threat of sanctions has led the business community to push for changes in the policy process.

Enforcement

To date, there has been little enforcement of the Conformity Rule. EPA explained that strict enforcement is not possible at this stage because of remaining confusion about what the rule actually requires.

Several participants suggested that EPA's stance was counterproductive. They suggested that EPA should either (1) drop the promise of punishment and thereby eliminate the incentive to distort models, or (2) enforce the law, demonstrating that the rule must be taken seriously. If the

federal government does not start to block big projects, then is unreasonable to expect that the conformity process will have an effect on the decision-making process.

Transparency and Access to Data

A final key issue was public access to models and data. Several participants argued that the lack of transparency and accountability in modeling is at the root of many of the problems identified by the group. Universities and citizens' organizations need access to data, a detailed accounting of assumptions, and the models themselves in order to verify MPOs' modeling results and fully participate in the analysis of policy/investment alternatives. But large financial hurdles block universities and non-profits from gaining access to data sets and models. When asked for data, MPOs become very defensive, perhaps because they fear being sued.

Opening the modeling process up to public scrutiny can bring big improvements in the quality of the process. Through conformity guidance and rules, the federal government should promote this.

Panel 2

Integrating transportation, land use, and environmental analysis

The aim of this session was to generate a discussion of ways to make better use of models and analysis in policy making, by examining innovative approaches to coordinating these typically fragmented processes. Mark Brucker and Ann Stevens served as co-moderators for this session.

Introduction

Mark Brucker, U.S. Environmental Protection Agency

Better models do not necessarily lead to better decisions. In the case of environmental analysis for transportation planning, air quality is too often used as proxy for every environmental concern. Ostensibly this is the case because there are no federal DOT requirements to examine other environmental impacts of transportation plans and only rarely do state and local governments demand such analyses. Sometimes, the planning assumption is that air quality conformity addresses all environmental impacts and this clearly is not the case. It ignores project impacts on water quality, open space, habitat, biodiversity, greenhouse gases, aesthetics and other factors related to quality of life.

Ann Stevens, Consultant

Greig Harvey sought to improve the link between models and decision-making. The *Manual of Regional Transportation Modeling Practice for Air Quality Analysis*, which he co-authored, enumerated strategies for improving modeling in the near term to address key policy issues. These include adding feedback loops in the 4-step process to every regional model, improving input databases, incorporating into forecasting models variables recognized as determinants of travel behavior, shifting to a network orientation, and integrating into the process better models of land use allocation.

Case Study in Advocacy Modeling: Portland

Keith Bartholomew, 1000 Friends of Oregon

The proposed Western Bypass Freeway inspired 1000 Friends of Oregon to formulate an alternative proposal, called LUTRAQ (for “Land Use, Transportation, and Air Quality”), and develop modeling improvements needed to forecast its impacts. The ultimate demise of the Western Bypass and adoption of the LUTRAQ alternative was affected principally by the actions of transportation advocates working both within and outside of the officially sanctioned model-driven process. This is a story of how a transportation advocacy organization used modeling as a tool in the decision-making process.

Washington County, Portland Metro, and the Oregon Department of Transportation agreed to build the freeway after publication of modeling analyses supporting the project. These analyses assumed that most future growth would occur at the region’s fringe. In response, citizens’ groups successfully sued for access to the decision-making process. Soon, however, they discovered that the process itself was fraught with limitations that would predetermine the outcome in favor of the freeway.

To overcome these limitations, the advocates worked to convince the state’s Land Conservation and Development Commission to adopt a progressive transportation planning rule, to require local land use and transportation plans to seek to reduce auto dependency. At the same time, 1000 Friends of Oregon began the LUTRAQ study in 1990 to develop transit- and compact growth-oriented alternatives to the freeway. We began with the identification of vacant and underutilized

lands, conducted a market analysis, constructed a new land-use plan, and developed a slate of supportive pricing and other policies. We also worked with Metro staffers to modify their models for greater sensitivity to pedestrian design and land use mixing—key features of the advocates’ plan—and tested the LUTRAQ alternative. The analysis revealed that it was substantially superior to the bypass on virtually every score, even in the area of traffic congestion.

Buttressed by data supporting the reasonableness of the LUTRAQ alternative, the State was forced to include the alternative in their evaluation process. Still, the advocates realized that without grassroots activism and backing, there was little chance that the State would select the LUTRAQ alternative. To cultivate this support, 1000 Friends of Oregon joined forces with Metro, which by that time was pursuing a remarkably similar agenda. Metro incorporated the contents of the LUTRAQ alternative into its conceptual land-use/transportation plan, the Region 2040 project. By its skill in obtaining political support for its plan, Metro secured adoption of its growth concept by the Metro Council. With Metro now squarely opposed to the freeway, the State abandoned its support for the project in June of 1997.

While it was a modeling analysis that undergirded the original proposal for the bypass, it was also a modeling analysis of the LUTRAQ alternative that gave politicians that were tentatively supportive of our position a safe place to land. By articulating an alternative to the bypass and demonstrating its viability through modeling, we made it much easier for political supporters to come “out of the closet” in our favor. But modeling, by itself, would not have been sufficient to net the results we achieved. Also necessary was the subjective, qualitative, and value-driven judgement of citizens and politicians that building communities was just a better idea than building a freeway. In addition, citizens’ advocacy groups had to be strategic about jumping in and out of the officially sanctioned “process box” in order to get their agenda adopted.

Keith Lawton, Portland Metro

Portland is not typical of most metropolitan areas because it has good political leadership that is out ahead of planning professionals and a proactive grassroots constituency which does not consider itself a hapless victim of trends and suburbanization. Land use, urban design and the transport system are key policy issues in the Portland region. LUTRAQ started Metro’s involvement in land use and urban design issues; Region 2040, the Metro planning process in which LUTRAQ was incorporated, accelerated that involvement. One of the things Metro learned through these efforts is that developers are not necessarily opposed to regulations governing land use and design; they primarily want to understand the logic and learn the rules so they can operate effectively within the system.

Related to land use and urban design questions, Metro is confronted by three issues. First, although it can be demonstrated that urban design affects auto ownership and travel decisions, how can analysts isolate the phenomena of self-selection? Surely this is happening to some extent. Second, it is difficult to model responses to policies. Models say little about how to realize the assumptions on which their outputs are based. Metro is building a series of sequential models to evaluate the extent to which the region is making progress toward its land use and urban design goals. Third, at what point does mixed-use have utility? It is somewhere between a two-jobs/two-households and 2,000-jobs/2,000-households, but where? Metro is considering this question through the development and use of a pedestrian probability model.

Metro is exploring several new approaches to help it examine emerging policy questions, such as congestion pricing. Metro is looking at activity scheduling, activity modeling, and tour-based models and doing it with a utility maximization approach because there are few experts in the rule-based satisficing approach. With the help of many individuals, including Greig Harvey, Metro essentially now has simultaneous activity pattern, time of day and primary stop, mode and destination choice models.

Discussion

The following issues were raised in the discussion that followed:

- *Transferability.* It is difficult to judge how applicable the lessons of Portland are to other areas, since every region has a unique set of opportunities and challenges. The urban growth boundaries, governance structure, political leadership, and resources available planning are unique characteristics of Portland that differ from most regions. But ten years ago, Portland's modeling and planning capabilities were not much different from those of other regions, so there is hope that other regions could replicate these outcomes. Good policy making might not be so difficult to achieve today because in some ways the issue of land use is easier to broach now.
- *Funding.* What resources were required for Portland to carry out its visioning and modeling processes? Modeling was a relatively small part of the decision making process. The cost of the political process and public outreach amounted to approximately \$1 million per year over 2-3 years.
- *Implementing land use plans.* What does it really mean to do a land use alternative? After all, it is impossible to control outcomes of land use plans like we can for transportation plans. Metro first asked, "where does the region want to go?" and then annually collected, and still collects, data to gauge whether it is getting there. Metro is also constructing housing choice models primarily to understand how the system works and operates proactively to recruit developers willing to build the type of projects the region wants constructed.

Modeling Needs in the New York Metropolitan Area

Therese Langer, Rutgers University Environmental Law Clinic

The Tri-State Transportation Campaign is a consortium of thirteen environmental, planning and transportation public interest groups founded in 1992 to, among other things, oppose highway capacity expansion, promote demand management, advocate the proper pricing of transportation facilities and services, overhaul state budgets, and advance rail freight in the New York Metropolitan Area. Unfortunately, the models used in the region do not allow an examination of the potential trip-making effects of these policies. This has significantly hampered the organization's advocacy efforts.

To address these modeling needs, the Campaign hired Greig Harvey to adapt his STEP model to the region, while the Environmental Defense Fund (EDF) was to piece together a network-based model to integrate with STEP. The design would allow the feedback of travel times and provide the capability to conduct corridor analyses. After a considerable delay, this project is once again moving forward, with David Reinke now taking a lead role. In the meantime, Tri-State has participated in collaborative efforts to patch together available modeling tools. The outcomes were not entirely satisfactory, due to the limitations of the models available.

Numerous examples illustrate why we are eager to have a model in place. Policy debates surrounding implementation of congestion pricing on New Jersey toll roads and the institution of tolls for East River crossings would benefit greatly from the capability to model alternatives. The Campaign has challenged plans to expand capacity on the Goethals Bridge from New Jersey to Staten Island, contending that it would not improve congestion in the corridor. Instead, it advocated a combination of variable tolls, innovative transit services and trucking alternatives to address the problem. While Tri-State was successful in raising the issue with both the Port Authority and the public, in the end, without a model to answer specific questions about the alternative proposals, the organization was unable to affect the outcome of the final environmental impact statement.

After completion of the STEP model, Tri-State should have a much better picture of the trip-making effects of pricing measures in particular, along with their impacts on air quality, congestion and equity of the system. Unfortunately, we will not have a picture that reflects the potential for increased use of alternative modes other than transit. This is not an inherent limitation of the STEP model, but rather reflects the increased data needs for a second round of STEP applications in the region.

Beyond asking what the models will provide, a bigger question concerns how the models will position Tri-State in the policy debate. While they should shape Tri-State proposals on a number of issues, they will also raise expectations. Policy makers will soon begin to ask important quantitative questions and having serious answers will be essential, though not solely sufficient, to win the debate.

Jeffrey Zupan, Regional Plan Association

Travel demand forecasting in the New York Metropolitan area is now and has for some time been in a woeful state. Basic to the problem is the absence of a truly regional MPO. In the early 1980s, the MPO covering the tri-state region, the Tri-state Regional Planning Commission (TSRPC), was disbanded, in large part a result of the desire of some sub-sectors of the region to be independent. Back in the late 1960s and early 1970s at TSRPC the work was done in the tradition of earlier modeling in Chicago and Pittsburgh, done by many of the same people brought to work at TSRPC. But modeling in the region is difficult, in part due to the large size and multiplicity of modal choices in the New York metropolitan region. TSRPC conducted a massive household travel survey in 1963, consisting of one percent of all households in the region. It became the prime source of trip data, along with the census work trip data. The household survey was a rich, but aging data source. But with time and the shift to more administrative functions brought upon by federal requirements, both the innovation at TSRPC and TSRPC itself died, and the innovators left for other more promising venues.

Throughout the 1980s, TSRPC's replacements, the New York Metropolitan Transportation Council (NYMTC) and the North Jersey Transportation Planning Authority (NJTPA), did little in the way of data collection, modeling and related activities. The southwestern portion of Connecticut was divided into a number of small MPOs, and also has done little data collection or modeling in almost 20 years. The mid-1990s has seen some small signs of progress. Prodded by federal impatience, NYMTC is developing a regional model, but it is not yet operational, having taken a great deal of time to develop, and there is no expectation that it will contain many of the innovative features such as land use feedback, non-motorized travel, or market-based policy testing. The NJTPA still relies on modeling by the NJDOT, which is largely highway oriented and does little to acknowledge the more than half million trips made between New Jersey and New York each weekday.

Both the major transit agencies, the MTA in New York and NJ TRANSIT in New Jersey have developed their own capabilities in this field. The Port Authority of New York and New Jersey had done the same, but an emasculation of its planning functions by a budget-conscious management has ended what had been a high quality, well financed set of activities.

What we have seen then in the last two decades or so, is the modeling breach filled by individual agencies collecting data and constructing models for their own narrow purposes. In addition, other travel forecasting has been done for individual projects in specific corridors. The one most conspicuous exception to this sorry situation has been the agreement on the part of both MPOs and the operating agencies to agree on population, employment and resident labor force projections developed by an outside consultant, Urbanomics. These are used for all the MIS and corridor planning studies in New York and northern New Jersey. But these stand-alone activities suffer

from self-isolation, and cannot take advantage of the synergies that can be offered when modeling a regional transportation network.

Today, there are many transportation decisions that could benefit from up-to-date travel demand forecasting. Numerous highway corridors in the region are in the midst of Major Investment Studies, including the Staten Island Expressway, Long Island Expressway and the Cross Bronx Expressway corridors. Others are the subject of controversy. The Port Authority wishes to build a second bridge adjacent to the Goethals Bridge connecting Staten Island and New Jersey. The two state DOTs look toward construction of added lanes for HOVs as the alternative of choice, claiming that they are environmental correct.

One HOV lane -- I-287 in Westchester County -- has been stopped after protest from community groups and environmental and transportation advocates. The successful technical argument (in contrast to the political ones) was that other less costly actions including TDM, TSM, market-based strategies, and more transit service could reduce the peak hour traffic sufficiently to relieve congestion to acceptable levels. The models in the region cannot demonstrate this now. As a substitute, the successful argument was made to New York Governor Pataki on the basis of simple logic, not models. "Governor, all that needs to be done is remove enough traffic so that congestion was reduced to summer commuter levels." He got it immediately, in contrast to his Department of Transportation who opted for the expensive, \$400 million HOV alternative. It was reasonable and sensible and logical to the Governor and so he killed it. These parametric analyses, and other "short stubby" models, to use William Alonso's words, have had to serve in place of network driven, multi-step models. They can be effective. Yet, this type of logic will not be enough when making complex decisions about complex networks that could cost upwards of a billion dollars or more. And there are many such projects in the New York region.

What is the lesson in all this for modelers? The first reaction may be -- don't take a job in New York. But there are others, as well. Models for the New York region need to be robust enough to withstand scrutiny, but simple enough to be clear to decision-makers.

Models need to be able to test sensitivities of key variables and show that the models give reasonable results. At NJ TRANSIT this was done when demonstrating the travel demand results of its trans-Hudson models. The result was a room full of knowledgeable people nodding affirmatively and saying, "that seems about right." What more could or should a modeler ask for?

Decision-making tools for setting priorities need to be in place. At NJ TRANSIT the process of selecting trans-Hudson investments was aided by using four clusters of normative measures -- financial, traveler benefits, political value, and ridership -- which were then given alternative weights for each cluster to test the robustness of the "winning" investment. In other cases, the use of non-traditional approaches may be appropriate.

A further note -- modelers do not check models enough by "backcasting" to test how well their models would do in "forecasting" the past. It can be a powerful calibration and validation tool.

As we start thinking more outside the box in travel demand modeling, we must be open to testing possibilities that have never been a part of the discipline. Transit-friendly designs, congestion relief pricing, "cashing out" of free parking, land use feedback, alternative work schedule and telecommuting effects, are just some of those that come to mind. It will be not good enough to say we cannot or will not test something because it is beyond the range of existing variables. When we get outside the box in this way, we will then be using our models to do what Grieg Harvey did so well. Advocate from a position of strength.

Discussion

The following themes were raised in the discussion that followed:

- *Applicability of Portland strategy.* In response to a question about whether the strategy employed by 1000 Friends of Oregon would work in New York, Michael Replogle responded that developing a full-blown alternatives analysis for the entire region is too complex a task. He expects, instead, that the approach will be along the line of sub-area studies. The situation in New York is exacerbated by the lack of both a regional database and efficiency in its planning processes.
- *Specifics of New York models.* In response to a question about what kind of model the Tri-State Transportation Campaign would like built, Langer replied that they need models that can evaluate a multiple policy interventions across a wide range of circumstances. Looking at pricing measures on the Goethals Bridge may be relatively straightforward, but understanding the impact of tolling the East River crossings is very complex. Replogle detailed how EDF is assembling a number of data sets to allow it to do pivot point modeling based on Greig Harvey's STEP model. The New York Metropolitan Transportation Council, is also developing a new "best practices" model for the region based on the traditional 4-Step model. Zupan added that while it would be preferable to see modeling standardized across the region, the problems are of such a complexity that there is a need to choose different tools to match each particular challenge.
- *Fragmented and proprietary modeling.* There have been many models developed for portions of Metropolitan New York. However, they have all been project or policy focused, very narrow and constructed outside the framework of a regional model. Curiously, all of this modeling was commissioned by agencies that considered the work private and part of their own internal decision making. Consultants who do the work are often precluded by contract from discussing the work or releasing any information about it; this practice is fairly standard among planning agencies. It is not entirely inappropriate for agencies to guard their analyses, but it is difficult to determine where the line should be drawn. Zupan disagreed, arguing that there is no justification for such policies: "the more sunlight allowed to shine on the policy making process the better it is."

Perspectives on Transportation, Land Use and Air Quality Modeling

Frank Koppelman, Northwestern University

The systems that planning professionals model are enormously complex. This limits what each model and sub-model can deliver. These limitations stem from the simplifications adopted and their unknown implications; a broad range of behavioral assumptions; errors in measurements; and technical difficulties inherent in estimation. While these limitations cannot be eliminated, analysts have a responsibility to use the best available technology and resources to improve their models incrementally. This requires a reexamination of the underlying theoretical constructs; continual efforts to develop technical and analytic model enhancements; clear and balanced presentation of model capabilities and outputs; and honest incorporation of professional judgement by analysts.

Great economic forces are driving change in the public sector. Sometimes, he added, this happens outside the scope of public review because civil controls are not sufficient to properly channel these forces. Changes in household structure and lifestyle preferences over recent decades are altering demands on the transportation system as well as where and how people choose to live. Technology is also changing rapidly. While technology promises to provide new tools for improving transportation, it can also have unintended effects that may alter dramatically both the nature of the problems transportation professionals face in the future and these professionals' ability to address them.

Professionals must recognize the power of human preferences. A preponderance of evidence indicates that people will seek ways to act as they prefer in spite of interventions aimed at inducing

different behavior. Individuals have demonstrated a desire to consume greater amounts of land for their residences and rely on automobiles to a greater extent than what society prescribes. While it can be argued that public policies have encouraged these behaviors, the trends continue even after governments intervene to change them. Major incentives, ones that more closely align the best interests of consumers with publicly desirable outcomes, are necessary to dramatically impact behavior. However, because most of these incentives are negative in nature, they are politically unpopular (e.g. congestion pricing). However, the alternatives to pricing – capacity expansion projects – are also unpalatable in many ways. Unfortunately, there are strong political forces that favor highway construction because it serves powerful special interests. The challenge, therefore, is to find balance in the policy debate.

Modelers' apparent inability to learn the "Law of Unexpected Consequences" is particularly troubling. It is amazing that the lack of success in attempts to tame congestion through capacity expansion seem to come as a surprise to professionals of a community that has long understood the phenomena of induced demand.

Planner/analysts have two important responsibilities. The first is the duty of the professional to maintain an open modeling process. While, indeed, efforts to conduct business in the public view invites criticism and can make agreement more difficult to reach, operating behind closed doors creates opportunities for manipulation and abuse of the process. This presents an important challenge for professionals to conscientiously justify closed deliberations when and if they are necessary and endeavor always to make every process as accessible as possible. The second category of responsibilities is the need for pluralism in the modeling process. It is important to encourage peer reviews, support collaborative efforts and recognize the scope of policy options. Professionals must, above all, respect and encourage input from all sides of an issue regardless of their advocacy position.

Greig Harvey brought joy, excitement, intensity and commitment to his work, and to the discussion of these ideas. This conference is an opportunity to affirm the importance of his values and objectives.

Michael Replegle, Environmental Defense Fund

The "old style" of transportation planning in the United States focused mostly on project planning and used aggregate models for engineering trend projections while ignoring major interactions between travel cost, travel time, land use and travel behavior. Modelers assumed fixed forecasts for land use pattern and designs, travel costs, travel incentives, essentially assuming that the future can be nothing other than an enlarged version of the present and determining the entire analysis process suspect from the start. This old paradigm was also unable to describe the impact of pricing changes and introduction of new kinds of information systems. Analyses performed in this mode were frequently used to obscure choices rather than elucidate them. Lack of oversight in the process also led to misuse of models. Finally, the old way of modeling was rooted in a technocratic culture, and used technical tools effectively to exclude the public from the decision making process. In some parts of the country advocates are still engaged in a struggle against this approach.

A new emerging planning approach is "vision supportive." This planning approach strives to recognize past choices and current trends clearly, without condemnation, and relies on them to discern future choices. It accepts that planning must work within the current context with the promise that it will itself create better planning conditions. It acknowledges the limitations that the uneven distribution of power places on planning and that incentives are powerful and even small ones have the strength to affect system change. Perhaps most importantly, vision supportive planning "promotes integrity of analysis and honesty about uncertainty and the complex dynamics of change."

While collaboration is a great model for working toward a common vision, given the nature of power, conflict must also be acknowledged for the creative role it plays in the transportation planning process. The analysis of alternatives and recognition of interdependence of the factors that affect travel demand is threatening to powerful political forces that benefit from the old style of modeling. After all, information and analysis are powerful tools for shaping public opinion and engaging communities or excluding them. Collaboration requires a mutual respect among the parties and sometimes this too must stem from conflict. This was the case in Portland, where the successful collaboration of advocates and public agencies began with litigation. Collaboration also requires a search for common goals and the analytic process, if well crafted, can become a catalyst for this pursuit.

Professionals can and should contribute. There are several things they can do to improve analytic integrity. Planners can, and should, recognize the limits of transportation models while at the same time increasing their utility by integrating tested techniques and developing and incorporating new ones. These include the use of deeply nested discrete choice models, individual choice sample enumeration methods, and efforts to measure and incorporate key policy attributes, e.g. pedestrian friendliness. Planners also can, and should, work to assure more democratic access to models and their input data sets and foster the institutionalization of independent modeling reviews to discourage abuses. *Pro bono* oversight is an ethical obligation of the modeling profession.

Planners should not to abandon hope of influencing motor vehicle dependence and use – we have had numerous successes in the U.S. and abroad. However, there are no silver bullets. The following is a list of action items that promise to lead towards more sustainable transportation and land use.

- Promote voluntary incentives for sustainable community pilot projects, regional partnerships and LUTRAQ-type planning.
- Implement and enforce provisions of CAAA, ISTEA, NEPA and Title VI of the Civil Rights Act.
- Form local and regional leadership coalitions to develop alternative land use and transportation strategies and develop collaborations.
- Provide incentive grants and governance frameworks to link local land use decisions with transportation investments.
- Institute pricing reforms with more private capital, information and performance incentives.

Discussion

The following themes were raised in the discussion that followed:

- *Federal influence.* In the past, federal land use and environmental planning incentives were very influential, but these have disappeared. A new program to fund smart-growth regional planning could prove highly beneficial. There is money in the proposed HUD budget that would fund collaborative planning efforts under the authority of the Community Development Block Grant program – this could turn out to be an important program.
- *Behavioral components of models.* Several non-economic factors are important for understanding how individuals make locational decisions, including school quality, level of crime and ethnicity. Unfortunately, we don't have a thorough understanding of these mechanisms, and this dearth of knowledge demands investment in data collection and social science research to provide answers. On the other hand, much pertinent information is already available (e.g., it

is known that people prefer to live with those of like race and economic class). The more difficult task is designing acceptable interventions that can actually alter behaviors judged to be undesirable.

- *Evolutionary science.* Ecological models possess certain characteristics, such as path dependence, that are often missing from economic models. Ecological models have much to lend to behavioral research, but the possibilities have not as yet been fully explored. TRANSIMS uses a systems approach that may start to incorporate evolutionary approaches.
- *Don't put models in the path of conflict.* Good modeling threatens local interests; the profession needs to find less threatening ways to practice. Changing project funding mechanisms could fully fund the construction industry without having to build bad projects. Professionals need to show and demonstrate this to reduce resistance to good planning.
- *Models need more simplification, not more complexity.* There is a curious prejudice that modeling is based on natural laws, analogous to physics, and that it will lead to the discovery of some underlying principles. This may happen, but right now, this complexity is getting in the way. Perhaps modeling is like an accordion: there is a tension between expanding one's understanding and the need to squeeze something useful out of it.

Panel 3

Analysis of intercity transportation problems

This panel discussed the state-of-the-art and needed improvements in the analysis of intercity transportation problems. Cliff Winston started by tracing the benefits of deregulation in several transportation modes. Next, Daniel Brand discussed efforts to model the demand for high-speed rail services. Geoff Gosling presented the latest efforts to model travelers' location and mode choice for air travel. Edward Jordon concluded the panel by providing some additional observations.

Intercity Demand Models and the Economic Effects of Deregulation

Cliff Winston, The Brookings Institution

The transportation research community should be asking itself: what have its knowledge and models contributed to the \$7 trillion national economy? What have intercity demand models done to improve transportation policy and economic growth? This talk will explore these issues through models that examine the deregulation of intercity transportation services.

Currently, models are not able to forecast the economic benefits of deregulation reliably. The best we can offer from these models is a retrospective of past deregulation efforts, helping provide an understanding of what has transpired. This has relevance today because it helps provide a continuing impetus for deregulation, in the face of efforts to re-regulate certain transportation sectors.

Because regulation and deregulation never existed at the same time, it is difficult to compare the two. One needs to create a counterfactual scenario in order to assess the effects of deregulation.

The models used in this study are based upon a welfare economics framework:

$$\Delta\text{Welfare} = \text{Compensating Variation} + \Delta\text{Profits}$$

where the "compensating variation" (or consumer surplus) is the amount of money a traveler or shipper would have to be given after a price and/or service quality change to be as well off after the change as s/he was before the change. Compensating variation is the integral over prices of the sum (for each mode) of the change in welfare for each consumer of transportation.

For passenger travel, the consumer surplus is estimated using a multinomial logit model for four modes: air, automobile, rail, and bus. The travelers' utility for each mode is a linear model based on fares, travel time, service frequency, and socioeconomic characteristics.

For freight, the consumer surplus is estimated using a multinomial probit model for three modes: truck, air, and rail. The shippers utility for each mode is a linear model based on direct costs, travel time, reliability, and shipper characteristics.

In total, deregulation of these three sectors produced roughly \$50 billion (1996 dollars) in benefits to the economy. The models indicate how these benefits originated:

- *Airline deregulation* produced benefits of \$4.3 billion to \$6.5 billion (1990 dollars) from lower fares; \$8.5 billion from higher frequency; and -\$1 billion to +\$1.8 billion in reduced (or increased) travel time. Of these, the improved service frequency yielded the greatest benefits. Note that the travel time effects could be improved by implementing congestion pricing.

- *Rail freight deregulation* brought \$9.3 billion in benefits from service and reliability improvements, and -\$2.1 billion to +\$0.4 billion in benefits from price changes.
- *Trucking deregulation* produced \$7.8 billion in benefits from reduced prices, \$6.0 billion from reduced private truck costs, and \$1.6 billion from improved service time and reliability.

The models also indicate how the benefits of deregulation were distributed. Key findings were that:

- Large hubs gained more than small hubs from airline deregulation
- Business travelers gained from greater frequency, pleasure travelers gained from lower fares
- Large shippers gained more from freight deregulation than small shippers
- Third party institutions are evolving to generate stronger market forces

There are a number of further issues in intercity demand modeling that need to be addressed:

- Data are scarce, and assembling databases can be costly. This is particularly a problem in freight.
- Market sizes are usually held constant, so models don't capture changes in trip generation rates. But the effect of deregulation is to expand markets, so models need to be improved.
- We need better ways of assessing the broader impacts of transportation, such as on land use and production patterns. For example, lower airfares could radically change locational decisions, but these are not captured by the present generation of models.

Modeling the Demand for High-Speed Intercity Rail Services

Daniel Brand, Charles River Associates

Forecasting travel demand for high-speed rail (high-speed ground transport or HSGT) is necessary to determine the feasibility of constructing a rail line in the corridor from San Diego to Sacramento. However, this is difficult because HSGT does not yet exist in California. One of Greig Harvey's important contributions to the study of intercity travel mode choice was the inclusion of properly calculated access travel time in the analysis.

Some data on intercity travel patterns is available that provides insight into intercity mode choice. As distance increases, the mode share of air travel increases. Air doesn't compete well with the automobile in California until trip distances reach 300 to 400 miles, at which it captures 50-60% of the market. In shorter, 180-200 mile California markets, air travel gets only 10% of the market.

Air travel's mode share is low on shorter trips because their low volumes can cause fares to be quite high. Also, in many shorter-distance markets, lack of air carrier competition further boosts fares, which reduces the overall mode share of air travel. Business trips have a higher mode share for air transport than do non-business trips, particularly for shorter trip distances.

Information on travel patterns particular to California are needed to assess the feasibility of HSGT. In the Los Angeles-San Francisco market, the air transport mode share is two times that in the comparable New York-Washington D.C. and New York-Boston markets. In California, Los Angeles-San Francisco, San Diego-San Francisco, and Los Angeles-Sacramento are the largest markets for air transport. The mode shares of air business travel are two or more times those of non-business travel.

Three approaches have been used for modeling mode choice behavior for intercity travel in California: multinomial logit, nested logit, and binary diversion models. In each, all modes are as-

signed average travel speeds and associated modal constants (parking time and costs for automobile; access times and costs and wait times for HSGT, bus, rail, and air). The three approaches differ as follows:

- *Multinomial logit model.* Directly allocates future travel in each market among auto, air, rail, bus, and HSGT. This approach does not effectively represent differential rates of substitution, and has problems due to the independence of irrelevant alternatives (IIA). That is, the introduction of a new mode diverts travelers from existing modes in proportion to their existing mode shares.
- *Nested logit model.* Allocates future demand to modes in two or more stages. One possibility is to represent the traveler's choice whether to drive or take a common carrier; and then to choose which common carrier to take (air, bus, rail, or HSGT). This approach can avoid most IIA problems, but is still difficult to check for reasonableness.
- *Binary diversion model.* Diverts projected future demand from each existing mode to HSGT using separate binary choice models. Based upon observed behavioral data, value of time is estimated separately for each market segment (which can be categorized by business vs. non-business, and currently used modes). Stated preference surveys are used to determine the binary choice relationships used in each model, since these can't be estimated using observed modal shares when there are more than two choices.

The third approach is preferable because it makes use of the important behavioral information travelers have already provided by their revealed modal preferences for intercity travel. Current and future air and auto users will divert to high-speed rail in different proportions because they have different values of time, and they place different value on the convenience and flexibility attributes of private vehicles relative to the common carrier alternatives. Business and non-business travelers also place different values on the attributes of the various modes.

Using the third type of model, analysis of HSGT in California indicates that farebox revenues should be able to cover operating costs and make a significant contribution to (but not cover) capital costs. But care must be taken in efforts to maximize the commercial benefits of the HSGT system. Setting fares to exactly maximize farebox revenues will reduce the mode shift from air and auto, thereby reducing the public benefits of the system.

The approach presented here has been used in forecasting HSGT ridership and revenue in many states and countries, including the most recent California high-speed rail forecasts. The resulting models provide information for designing new systems that maximize ridership, revenue, and the public benefits that justify public investments in new modes.

State of the Art of Airport Choice and Ground Access Models

Geoffrey Gosling, University of California at Berkeley

The need to predict how air travelers will choose between multiple airports serving a region, as well as their choice of ground transportation mode to travel to and from the chosen airport, arises in both regional airport system planning and planning studies at individual airports. However, these issues are important in a wider context than airport planning. Major commercial airports are some of the largest trip generators in a metropolitan region, and the airport choice process is a key element of the larger choice process involving intercity travel behavior.

Airport choice and ground access models have applications in many different planning contexts:

- *Development and operational planning:* ground access facility requirements; environmental impacts and mitigation; effects of changes in rates & charges (parking, car rental, etc.).

- *Regional airport system planning*: allocation of regional demand (where will growth occur and when will a new airport be needed?); ground traffic generated by airports (important for air quality conformity issues).
- *Intercity travel demand analysis*: choice between air and surface modes (significant mode choice issues for trips between 200 and 500 miles); access to intercity terminals; intermodal issues.

Airport Choice

Travelers don't make a simple binary choice between automobile and air transport. They also choose which airport to use. They can take surface modes to the nearest airport, to a regional hub, or to their final destination. Their choices will be influenced by fare structures (is it cheaper to fly out of the local airport or the regional hub?); air service factors (flight frequencies, number of stops, fares, airlines); and accessibility (distance/travel time, parking cost and convenience, ground transport services). Smaller airports may be attractive because they have less congestion and cheaper parking, but large airports have better ground services. Typical models use very few variables: one or two service characteristics (e.g. frequency, fare, class of aircraft, etc.) and one accessibility variable (travel time, access utility).

There is a dynamic relationship between the airport choice process and the level of air service that is provided at specific airports. Airport choice models attempt to balance these demand and service levels iteratively. First, the spatial distribution of air travel demand is estimated. These demands and economic constraints shape the service levels that airlines are estimated to provide. These fare levels and frequencies are in turn fed back into another iteration of the demand allocation model.

Ground Access Mode Choice

Airport access mode choice is complex process involving a large number of modes, multiple service providers, and secondary mode access considerations. A nested logit structure is used to model this choice of access mode. For example, the first level choice may consider auto, door-to-door services, scheduled bus, or public transit. If the traveler chooses auto, then the second level may consider using a rental car, being dropped off, or parking for the duration of the air trip (in which case the traveler must choose between on- or off-airport lots, short- or long-term, etc.).

In constructing the nested logit model, analysts must consider the proper grouping of modes and submodes, and modal availability by origin and time of day. Utility functions should include modal service variables as well as the characteristics of the individual or group traveling to the airport (resident or visitor, trip purpose, income level, luggage, party size). Thought must also be given to whether to use a linear or nonlinear form for the utility function, and what data to use for calibration.

Models have been getting increasingly complex in terms of the number of modes they include, their degree of nesting, and the number of market segments they consider. However, there are still many issues that are not well-understood.

Technical Issues and Research Needs

Technical advances are needed in how airport choice models address flight frequencies, air fares (almost nobody pays the average fare), the effect of frequent flyer programs, and accessibility improvements (e.g. rail links to airports). Ground access mode choice models need improvements in how best to represent a nested choice process; and how to incorporate the use of rental cars, trips by greeters/well-wishers, automobile operating costs, and the effects of household or personal income.

Key research needs include:

- Improved understanding of the choice process
- Intermodal choice considerations
- Stability and transferability of model parameters
- Effects of access disutility on total demand (most air travel demand models do not include access costs and times)

Perspective on the Analysis of Intercity Transportation Problems

Edward Jordan, California Intercity High Speed Rail Authority

Back in the 1970's, demand modeling had a significant effect on the deregulation of the rail freight industry. The economic models created to analyze the industry were instrumental in advancing the cause of deregulation, and in retrospect turned out to be quite accurate. In 1978, it was clear that the strategy to create Conrail wouldn't work, but the models showed that deregulation was a viable alternative.

How do managers use the analyses that modelers produce? It depends on the integrity of the analysis. The public needs to "buy" the results. Costs of projects are very large, and examples like the Chunnel and the Los Angeles Metro don't build confidence that demand or cost forecasts are accurate. In Los Angeles case, nothing was wrong with the analysis methods themselves: the problem was with the underlying assumptions.

Fearing competition, major airlines helped kill the high speed rail project in Texas by contesting the project's underlying analysis; they will raise similar objections in California. It is therefore incumbent upon those of us analyzing high-speed rail to test all of our assumptions carefully.

High speed rail projections are difficult because of uncertainty about induced travel, central city access (where should a station be located in Los Angeles?), and the problems inherent in estimating demand for a service that does not yet exist. Californians are unfamiliar with rail, and the proposed high-speed rail project here will provide service never seen here before. This requires a process that is politically insightful and doesn't rely entirely on models.

The real issue facing modelers will be the integrity of their analysis, not necessarily their accuracy. Models will only be valuable to the extent that they reassure the public that the analysis of a project has been done in good faith and with integrity.

Discussion

The adequacy of the demand analysis for high-speed rail was a key issue during the discussion period. One participant expressed reservations about both high-speed rail itself, and the models being used to assess demand for it. He argued that high-speed rail is tremendously expensive for limited benefit, and that better cost/benefit studies are needed that include public subsidies. In response, it was argued that a thorough cost/benefit analysis has been done for high-speed rail, and that it shows net benefits.

Other comments included:

- *Returns to scale.* It is very difficult to start analysis on a new mode. At first, high-speed rail will serve only two cities, but as more stations are added, there will be returns to scale as the size of the market grows geometrically. Cost-benefit analyses that take into account only the earliest stages of a project will miss these synergies.

- *Poor analogies.* Passenger rail should not be compared to freight rail deregulation. Rail freight deregulation was implemented to save the industry from bankruptcy, not to provide direct benefits to the public; political decisions were made to leave shippers to their own devices.
- *Promising case studies.* The light rail extension to Newark Airport had a tremendous impact on ground access mode choice, and even changed demand for different levels of parking. The new main terminal at National Airport significantly improved access from the Metro station. Both were suggested as potentially rich case studies that could improve our understanding of access mode choice.
- *Broader scope.* Just as Gosling is pushing the conventional boundaries of how we conceptualize transportation analysis toward a broader picture of travelers' activities and choices, regional modelers should seek to expand their perspectives by including interactions with communication, longer-distance travel, and the broader economy.

Panel 4

The Role of Analysis in Transportation Pricing and Equity Decisions

The focus of this panel was what kinds of information and analyses can best help policy makers make sound decisions on pricing and equity issues. Michael Cameron started the session by recounting a collaboration with Greig Harvey on an analysis of the environmental and equity implications of road pricing. John Duve, Steve Heminger, and Fred Salvucci each approached the question of congestion pricing from different perspectives, and Brian Taylor explored equity issues in transit pricing.

Introduction

Michael Cameron, Environmental Defense Fund

Transportation pricing has been rising in prominence as a topic for public debate. Kenneth Small and William Vickrey advanced the theory of pricing in transportation policy, but until recently we haven't had real-world experience testing and applying these theories. Martin Luther King Jr. and Rosa Parks raised equity issues in public transit, but until recently pricing policy hasn't been part of the equity debate. Now concerns about both equity and economic efficiency are driving pricing strategies to the forefront of transportation policy-making.

On a personal note, I was hired by the Environmental Defense Fund in 1989 to study congestion and air quality in Los Angeles. It was clear that road travel suffered from market failures and that road pricing could play a significant role in their solution, but the lack of any supporting analysis left advocates in a weak position. But through great foresight, Greig Harvey had developed the necessary analytical tools. He collaborated with EDF to produce a report estimating the effects of congestion pricing on air quality and vehicle miles traveled in Southern California. This report, published in 1991, was the first time this type of analysis had been completed.

Having opened that can of worms, we turned our attention to equity questions: is pricing equitable or not? After a year of false starts and missteps in grappling with equity questions, we decided it wasn't our role to develop a standard of equity; instead we needed to provide information to decision-makers. With Greig's leadership, we developed a report estimating how the costs and benefits from pricing were distributed across income groups. Greig estimated benefits using willingness-to-pay for travel (area under the demand curve), and mined data to estimate cost structures by income groups.

This second report was issued in 1994 as *Efficiency and Fairness on the Road*. It found that pricing would improve efficiency and benefit all income groups, but not equally. The lowest quintile received 6% of the net benefits, while the highest quintile received 34% of the net benefits. The ultimate effects of pricing would depend on the purposes to which the revenues are applied. The report openly admitted that its equity implications were ambiguous.

Meanwhile, a little-known provision of ISTEA would fund congestion pricing demonstration projects. Now there are thousands of people working on this issue; in 1989 virtually nobody outside academia paid attention to it.

Another important issue that helped raise the profile of these issues was the litigation over equity issues in Los Angeles transit services. This lawsuit required an unprecedented degree of analysis, and made use of the analysis that Greig did for EDF.

Greig was an advocate of truth with openness and tolerance for different value systems. Each of us brings certain beliefs and predispositions to our work; our challenge is to advance these honestly.

The I-15 HOT Lanes in San Diego

John Duve, San Diego Association of Governments

In the I-15 corridor in San Diego, the high-occupancy vehicle (HOV) express lanes were being underutilized. It was thought that the entire system would perform better if use of HOV lanes was maximized. To accomplish this without eliminating incentives for ridesharing, the HOV lanes were converted to high-occupancy toll (HOT) lanes. These allow single-occupant vehicles to buy access to the express lanes for a price that is set dynamically to balance real-time demand against the requirement that free traffic flow be maintained.

There are some questions that simply can't be modeled given our current state of knowledge; willingness to pay for HOT lanes is one of them. In this case, the project itself is a real-world experiment that will help to advance the state of the art. Hopefully, lessons drawn from this experience will be useful in helping to make decisions about future projects.

Keith Bartholomew talked about a process box. Thinking about my role, I think I may have *been* the process box. From the box's perspective, there were three issues to think about:

- The trend toward emphasizing better system management over new capital improvements
- The need to be more specific about solutions; otherwise, what is the purpose of planning?
- The potential for ITS to have large benefits if existing models serve as a platform for real-time models.

During the morning peak, there is severe traffic congestion southbound on I-15. The primary lanes run at level-of-service F, while the express HOV lanes run at level-of-service C or better. It was becoming politically difficult to keep the HOV lanes open because they were seen as underutilized. Initially, elected officials didn't understand the concept of pricing, and didn't think there was anything to sell. But ultimately, they came to see selling extra space on HOV as a means for improving their utilization while preserving their benefits. The key to the success of the HOT lane proposal was that it preserved choice for travelers not willing to pay a toll. Goals of the I-15 project included maximizing use of the existing express lanes; relieving congestion on the primary lanes; and funding new transit and carpool services in the corridor. All revenues were to be used to further these goals.

In the initial phase, \$70 monthly passes were sold to 900-1000 vehicles. During this phase, carpooling rose unexpectedly. Rising carpooling was expected in the final phase because its pay-per-use structure would facilitate occasional carpoolers. But it was unclear why it grew during the initial phase.

Under full implementation, users will buy into the express lane by paying per trip via electronic toll collection. The number of participants will be unlimited, but variable tolls will be set to ensure free-flow traffic while maximizing carpools and transit use. Signs will show real-time toll prices, so that drivers can make informed choices about which lane to use. Fee levels will be based on real-time traffic to maintain level-of-service C. The minimum toll will be set at 50 cents, and the average rush-hour toll is expected to be \$3-\$4 (during major traffic incidents, the toll will be capped at \$8). Initially, prices will change at 30-minute segments.

The computer that sets prices uses a model, but the entire endeavor is a real-world model that can be used in the development of future modeling and/or management tools. Because fees will be determined real-time by a computer, we don't know yet what they will be. This experiment will show what people are really willing to pay.

Congestion Pricing on the San Francisco Bay Bridge

Steve Heminger, Metropolitan Transportation Commission

Just as we can learn from the success of the San Diego congestion pricing experiment, we can learn from the failure of the proposal to implement congestion pricing on the San Francisco Bay Bridge.

The Bay Bridge was seen as an ideal candidate for congestion pricing. It has severe congestion, multiple mode choices, and low potential for route diversion. Seventy percent of commuters in the corridor were already not driving alone: they were carpooling or traveling via ferry, bus, or rail.

The original congestion pricing proposal would have increased tolls on the bridge from \$1 to \$3 during the peak hour to raise revenues for necessary earthquake retrofits. Carpoolers would continue to use the bridge for free, and low-income drivers would continue to pay the \$1 toll during rush hour. Greig Harvey and Betty Deakin estimated that this fare structure would reduce rush hour delay by 40%, yielding significant public benefits.

The congestion pricing proposal was rejected in favor of a 24-hour, \$2 toll. Why didn't the proposal succeed? This talk will explore two contradictory questions: How was analysis useful to the project? And how was analysis irrelevant to the outcome?

How was the analysis useful?

Richness of detail. Greig and Betty enabled us to bring a richness of detail to the analysis backing our proposal that otherwise would have been lacking. Using PUMS data from the census, they estimated how people would be affected by the change, based upon their housing location, income level, etc. This enabled us to answer just about any questions that the public might raise, helped us to convey an air of authority, and increased the public's confidence that we knew what we were talking about.

Income. Equity is a critical question in pricing policy. Are the poor priced off the road? Analysts have always known that income is a critical travel choice variable, but generally haven't done much with it beyond simple axioms: if you have more money you drive; if you have less money, you drive less; if you have even less money, you take the bus. With the Bay Bridge project, we found that average peak hour commuter crossing the bridge had far over the median household income. This enabled us to do something useful with the data: (a) we demonstrated that a higher toll would mostly hit the rich, not the poor; and (b) it would hit some poor, but few enough to mitigate via a lifeline toll.

Choices. As Marty observed earlier, modelers shouldn't be asked to find optimal solutions, since these always involve political judgements best addressed through the political process. Greig and Betty's analysis didn't proclaim an ideal solution; instead, it helped clarify for decision-makers the tradeoffs that they had to balance. It showed that a \$2 rush-hour toll would reduce congestion 20%, which was probably not worthwhile because it was less than the natural variability of congestion on the bridge. A \$5 toll would clear out the queue, but would also clear out the MTC board by igniting a voter revolt. A toll in the range of \$3 to \$4, which would reduce delay 40-60%, made the most sense. Focus groups helped us settle on a recommendation of \$3, the same price the Golden Gate Bridge toll.

How was the analysis irrelevant?

Analysis vs. intuition. A major obstacle was convincing people that small changes in traffic cause big changes in delay. Most just wouldn't believe that a 6% reduction in traffic would bring such a

large time savings. Their intuition that we would need to price everyone off the bridge to reduce the back-up was too firmly rooted. We tried pictures to explain the non-linearity of congestion, but to no avail.

Analysis vs. ideology. Newspapers and politicians braced for a negative public reaction to our proposal; instead they got some surprising poll results: 60% of the public favored it. So, since the reaction wasn't bad enough, they poured some gasoline on the fire. Newspapers called us names, one state legislator asked "why doesn't MTC stop flagellating itself?" and another argued that "tolls are a polite form of highway robbery." In the end, our message wasn't simple enough to carry the day.

Analysis vs. MTV. In California, the public either makes policy directly by initiative or is consulted through polls by their elected officials. With most policymaking dependent on the public's limited time and attention, the winning side is the one that can define the debate with the simplest message. For the Bay Bridge congestion pricing project, the winning tag wasn't "congestion almost cut in half," or "soak the rich commuters," but "bureaucrats triple tolls." Guess what? We lost.

Conclusion: Can we do better for pricing?

Three lessons may help us do better in the future:

- *Experience trumps intuition.* As we have more successes other places (e.g. SR-91 and I-15) we will gradually turn the tide on the skeptics and build support for these proposals.
- *Even ideologues like win-win situations.* One problem for the Bay Bridge project was that everyone would pay the higher toll, but not everyone would benefit from it. With HOT lanes, motorists retain choice whether to use the toll lane, and even those who don't pay still get a faster commute. Finding ways to providing more choice will help pricing prevail.
- *Language matters.* We're all learning about the name game. In the ISTEA reauthorization debate it's no longer called "congestion pricing": it's now "value pricing" or "variable pricing." Pacific Bell doesn't use "peak surcharges," they offer "off-peak discounts." This provides a valuable lesson for the future of congestion pricing on the Bay Bridge. When the \$2 toll is set to expire, we will have an opportunity to keep it for the peak hour and offer a \$1 discount at off-peak times.

Dichotomy between efficiency and equity in public transportation

Brian Taylor, University of California, Los Angeles

One of the classic dilemmas in public policy is the dichotomy between efficiency and equity. But framing the issue this way implies a tradeoff that doesn't necessarily exist in public transportation. In transit, the two goals are often congruent, depending on how one defines "equity."

There are two contradictory definitions of equity in public transit: social equity and spatial equity:

Social equity. Here the unit of analysis is the individual or classes of individuals. The question of equity centers on how the quality of transit service, the fares paid, or the subsidies vary between these individuals or classes of individuals. Methods of analysis include comparing the per-mile fares, per-rider subsidies, or quality of service for different classes of transit passengers (express vs. local buses; rail vs. urban buses), and how this impacts different income, racial, and demographic groups.

Research has shown that long-distance/peak hour/rail trips tend to be cross-subsidized by short-distance/off-peak/local bus trips. The net effect is that lower-income riders pay more per mile than do higher-income riders. But this finding is seen by politicians as incendiary and of little practical use.

Spatial equity plays a much more dominant role in policy debates about the allocation of resources in public transit. Here the unit of analysis is the transit system or political jurisdiction, and not individuals or classes of individuals. The question of equity centers on how the allocation of transit resources varies among systems, counties, regions, states, or groups of voters. The focus is on how these resources are distributed to *suppliers* of transit services, with little regard for the enormous spatial variation in the *consumption* of transit service.

For example, the New York Metropolitan Transit Authority carries 24% of transit trips nationwide, but receives only 7% of federal transit operating subsidies. The San Francisco Municipal Railway carries about half of all Bay Area transit riders, but receives only 15% of the subsidies allocated to the region by the state Transportation Development Act; while Santa Clara Valley Transit carries less than 10% of riders and receives over 30% of the subsidies. The reason for these disparities is that residents, not transit patrons, are proportionately represented in our political system. One voter/one transit dollar is the guiding logic. Spatial equity seeks to give jurisdictions (and voters) a fair share of transit resources, whether or not they are effectively utilized.

This explains why social equity and economic efficiency have eroded despite increasing public financial support for transit. As transit service has suburbanized, each hour of service serves fewer riders.

Between 1989 and 1993, the 10 largest transit systems in the U.S. collectively cut service by about 1%, and saw ridership plummet by 11%, or 537 million annual riders. On the other hand, the smaller, suburban transit operators, serving the same metropolitan areas as the 10 largest operators, increased service by 8% over the same period, but saw ridership increase by only 57 million passengers. This effect of this transfer of resources contributed to a net loss of nearly 500 million passenger trips, and a decline in the productivity of the public's investment in transit services.

Subsidies and the Four Dimensions of Transit Costs

While virtually all public transit service is taxpayer subsidized, the costs of service provision vary significantly from place to place and from trip to trip. These costs vary in four ways:

- *Peak vs. off-peak travel.* Marginal costs are higher during the peak, because adding additional service during the peak often requires purchasing additional vehicles and hiring additional drivers.
- *Peak direction vs. back hauls.* Demand for transit services are highest heading into activity centers in the morning, and away from these centers in the afternoon. The marginal costs of heading in the peak direction are high because of the capital and labor costs mentioned above, and because this additional service is underutilized when the vehicle makes its return in the off-peak direction.
- *Long vs. short trips.* Long trips cost more to serve than short trips. When trips are long, seats turn over slowly, and more capacity is needed to accommodate a given level of ridership.
- *Transit mode.* Fixed-route buses are generally cheaper than rail or demand-response services. Buses are much cheaper to purchase per unit of capacity than rail cars. Buses also operate on existing rights-of-way, while most rail rights-of-way must be separately built and maintained.

Taken together, these four cost dimensions influence the cost of providing transit service dramatically. A long peak hour, peak direction trip on rail (such as a commute trip from Long Beach to downtown Los Angeles on the Blue Line) is far more expensive to serve than a five-block mid-day trip (e.g. on the MTA 204 Vermont bus line in the central city).

Because fares generally do not vary proportionately to the cost of providing service, subsidies per passenger vary significantly as well. Data from previous studies of transit equity, and the work I am doing in Los Angeles, show quite clearly that lower-income riders disproportionately consume off-peak, relatively inexpensive-to-provide services, while higher-income riders are more likely to consume expensive peak service.

The net effect is a regressive cross-subsidy from low-income to high-income riders. Transit-dependents pay more per-mile and per-hour for the transit service they consume, while per-rider subsidies tend to increase with ability to pay.

Transit systems are under tremendous pressure to spread their services to cover the entire area paying to finance them. They are also under pressure to make high-profile capital expenditures to achieve congestion and air quality goals. As a result, the political imperative of spatial equity pre-empts and supercedes both economic efficiency and social equity in an effort to give everyone their “fair share” of transit service, and to mitigate the externalities created by longer-distance, upper-income drivers.

What to do?

- One way of overcoming this problem may be to present economic efficiency and social equity arguments in tandem, to address policy concerns across the political spectrum.
- Another might be to shift the unit analysis from jurisdictions to individuals or households. Present data in terms of how much patrons contribute vs. how much they are subsidized.
- But district-based political representation will continue to make “mainstreaming” social equity a challenge for analysts and policy-makers alike.

Political Issues in Congestion Pricing

Fred Salvucci, Massachusetts Institute of Technology

The odds are against convincing the public that a tax is good for them. But a tax on congestion is unique in that it improves economic efficiency. Ways to improve its chances for success include:

- Provide choices
- Use revenues benefit those most hurt by the fees. Access is a unique good; we must ensure that we are not denying people access by pricing them off the road.
- Target congestion pricing in other areas like aviation (runway pricing). This is very compelling with virtually no equity issues. If we can't make congestion pricing work at airports, we should abandon the whole thing. If we show some dramatic gains in that area we may be more successful on the surface transportation front.

There are three groups to consider when thinking about congestion pricing:

The “tolled” are the people who stay on the road and pay the toll. In principle, their choice to remain on the road suggests that they are benefiting more in time than they are losing in money.

The “tolled off” are the people who shift off the facility to avoid the toll. They are worse off than they were before the toll was established, and are likely to be unhappy about it.

The “untolled” are the people on parallel facilities who are adversely affected by the tolled-off group. If they are transit riders, they may actually benefit from the higher services implemented to meet this additional demand. But if they are drivers, they may lose if their roads become more congested. They are generally outside the calculus of modelers studying the costs and benefits of pricing.

When politicians oppose congestion pricing, they know something that we should be thinking about: it would create many losers. The only thing that might make congestion pricing attractive for the tolled-off and untolled groups are the revenues that it generates and the benefits that these can bring.

The idea that tolls must be revenue-neutral is a mistake. If we are serious about equity, we need to use the revenues to address the needs of the tolled off and the un-tolled. Among the tolled-off, we shouldn't be looking strictly at the distribution of income. It would be better to recognize the degree to which congestion pricing may be limiting people's access in ways that are more significant than a simple income differentials might indicate.

Offering choices would makes this more palatable. People have a high value of time at particular times, and would value the choice to be able to pay to take a faster route when they want it. In Boston's western end (where there is a choice), there is greater support for tolls than on Boston's eastern end (where these is not a choice).

We shouldn't be timid about explaining why pricing is good for the public. But Americans are so adverse to pain that it will be very difficult. If congestion pricing is a good thing, then we're starting in the wrong place. If we're trying to balance environmental concerns with equity, then we need deeper subsidies for everybody (both central cities and suburbs).

Another place to start experimenting with congestion pricing would be the use of airport runways. The case for congestion pricing at airports is extremely compelling. It presents no equity problems, since most users are passengers (general aviation is a small but vocal minority). There is a place for people to go to save runway time: larger aircraft. This could be place to demonstrate dramatic efficiency gains without creating equity problems, and could change the policy landscape for congestion pricing elsewhere. But if we can't make congestion pricing work at airports, we should stop talking about implementing it on roads.

Discussion

The following issues were raised in the discussion that followed:

- *Explaining the non-linearity of volume vs. delay.* In Zupan's story about New York, the governor seemed to grasp quite readily the concept that only small numbers of drivers needed to be diverted to produce large reductions in delay. The Tappan Zee Bridge congestion pricing study has been able to explain this concept to citizens in focus groups. Why shouldn't the citizens of the Bay Area understand it with regard to the Bay Bridge? The problem in the Bay Area was that the political leadership never allowed an opportunity for debate. Many opposed congestion pricing because they saw it as a way for rich folks to buy their way out of a social problem.
- *Does congestion pricing of airport runways harm small aircraft?* The effect of general aviation on airport congestion is small; commuter aircraft feeder services create a much greater problem. Congestion pricing of runways could impact these services, so we should couple revenues with better services in such a way that isolated areas don't feel shut out of the sys-

tem. On the other hand, it was argued that gaming by airlines leads to too many commuter flights in small markets. Those markets can still get reasonable frequency in larger aircraft. We don't need to add runways... that creates new externalities. Congestion pricing at airports is feasible. There's a crude democracy to congestion.

- *Don't airlines already do congestion pricing?* Not really, airlines use peak pricing in their ticket sales. But airports don't charge peak prices airlines for the use of runways. Boston's Logan Airport tried it for a while, and the benefits were large, but the experiment failed politically. The current system of charging for runway use is based on weight, not time on the runway... this makes no sense in congested conditions.
- *Research on Pricing Equity.* In Europe and the eastern U.S., parallel tolled and untolled facilities can be found. But research about equity and other issues on these facilities is difficult because, while there is usually good data for the tolled facilities, but not for the free ones.
- *How much cross-subsidization is too much?* It has been suggested that some degree of cross-subsidization is acceptable, and is the necessary price of having suburbs finance transit services. But there is already a high degree of cross-subsidization and it is growing. At what point of this constant process of increasing subsidies for the rich and decreasing them for the poor does equity become worthy of attention? One way of looking at this is that the poor are actually being subsidized more in the aggregate, although the rich are being subsidized more per trip. It is a necessary bargain to ensure that everyone is willing to allow the continuance of subsidies. It is outrageous to cut service to the poor to benefit the rich. All should be made winners, even if the taxpayer is the big loser... we need to convince them that they're getting their money's worth.

Presentation & Forum: A New Paradigm for Modeling

Marvin Manheim, Northwestern University

The field of transportation today comprises two distinct branches, or thrusts. The *analysis* thrust includes travel demand forecasting and the *policy* thrust involves identifying the consequences of interventions for each actor, understanding the needs and concerns of actors and developing strategies to balance those concerns. A third thrust is needed that empowers individuals to make more effective use of analysis to inform decisions. It should focus on the ways people think and act and develop aids to thinking and acting that result in significant improvements in individual behavior.

Greig Harvey was able to build a bridge between analysis and policy, yet up until now there has not been a theory of how to do this. Professionals learned by trial and error. The theory and methods I am developing to fill this gap are called Cognitive Informatics (CI). CI examines how individuals think and act and uses that familiarity to provide computer support to help people be more effective. This research stems from an experience in the military where I came to believe that analysts exist to be misused by decision makers. The guiding principle of CI is to enhance the ways people work to increase their effectiveness and personal satisfaction as individuals and members of organizations. Achieving this requires helping them become reflective, proactive managers and thoughtful, yet action-focused.

In describing how people think and act, we borrow the idea of schemas from cognitive science. Schema theory maintains that information is stored in memory as schemas, or templates, with variables that are assigned values when the schema is recalled and activated. The values assigned to the variables contextualizes the schema. Summarily, then, an individual encountering a problem will think about it and in the process activate schemas which serve as the basis for acting.

The challenge for CI is to articulate schemas, or thought processes, explicitly into patterns which are available as templates that can be instantiated in use. A checklist is an example of a common pattern. Placing patterns in software makes them clearly explicit and readily available for execution. It also helps make tacit knowledge explicit and internalizes explicit knowledge so as to become tacit. It is important also to note that patterns are neither static nor absolute. Rather they should be shared, debated and allowed to evolve over time. In the current abstract discussion, patterns are simplistic. However, when individuals deal with practical problems, they develop groups of related patterns, called knowledge clusters, that work together in a very coherent way.

The last major element of this theory is the idea of a very important pattern (VIP). These reside at the top level of the pattern library and require development and broad circulation. One such VIP is Personal Action Management. This pattern reflects how each individual thinks, acts and operates. One pattern that may be applied in this larger VIP is jottings-issues-goals-actions-people (JIGAP). It is used by the speaker to take notes and distill those notes so that he follows up on them effectively. For those interested in personal action management, a useful shareware program available from Zoot at <http://www.zootsoftware.com>.

In closing, it is important to think about thinking. The mind is the first frontier and the last frontier of effective action in the world of policy and the world of analysis. It is our mind that is the most important tool. We need to understand it. We need to make it work for us.

Questions

Q: In this model, the actor is individual acting as an expert. It seems to create a separation between decision-maker and community affected by the policy decision. What is the role for the community in your model? How do the actors interact?

A: Each stakeholder is also in the learning process and has his/her own schemas for communicating with the decision-maker.

Q: In the 1970's, the curriculum at MIT was designed to foster innovation, but over time, engineering field seems to have shifted to promoting less flexible models and paradigms.

A: I'm interested in developing a way to educating an entire profession that can act creatively, not just a few leading individuals. It must be recognized that there are qualities that can't be learned. However, there are some that can be learned and we need to help teach them.

Q: What would you advise a young faculty member whose interest is in doing productive work, not just publishing.

A: It is hard to advise a young faculty member to engage in new research because it is very high risk. Academia has done a poor job addressing issues of interest to the outside world.

Q: In the transportation field, the culture of our decision-making institutions has long been focused on supply side project delivery. What would you propose to develop more effective decisions that consider a wider set of options?

A: Look at what can be done through legislation and litigation. We need to give analysts the power and confidence to do what they think is morally and ethically right, and we need to teach them a broad base of skills they need to be effective.

Q: Is the target user of this theory the decision-aider, or the decision-maker? What about situations about where there is no unitary decision-maker (e.g. metropolitan regions)?

A: The core theory has applications in both of these different domains. We recognize that there are multiple stakeholders; this theory enables us to be effective in that environment.

Q: How do you deal with power differentials and open decision-making systems in your scheme?

A: We address it by looking at patterns allow that coalitions to be built, and measures that make effectiveness possible within a dispersed network of power. The same principle applies even in open systems. See references by Dan Eisenberg in *Harvard Business Review* (circa 1987).

Q: Applying your model to this gathering tonight, is there some action or process you might distill from discussions so far for developing a better framework for analysis in transportation? Should we be developing a code of ethics?

A: That's one possible end product. Through our analysis, we need to bring out equity issues, and show explicitly ranges of uncertainty in forecasts. Our greatest challenge is how we can create an environment for more ethical and responsible analysis when staffs are scared for their jobs and budgets.

Open Discussion

Daniel Sperling (University of California at Davis) moderated the open discussion that followed, in which the following key themes were raised:

Access to Data and Assumptions

- *Data and full assumptions should be published.* Several participants argued that it should be standard practice to make available to the public the data, models, and assumptions used to assist policy decisions. Gaining access to these data is essential if there is to be an informed

public debate on matters of transportation policy. There are still formidable barriers to access even for well-funded watchdog groups and university researchers. It should be a relatively inexpensive endeavor for MPOs to publish their data on CD-ROMs or the Internet (as MTC has done).

- *Publication of data could be expensive.* Others argued that this would be quite difficult to implement. Compilation, documentation, and publication of data sets could take considerable resources. Model specifications and assumptions often evolve in a continual process as data and knowledge are refined, so it would be difficult to publish these on an ongoing basis. Finally, having to analyze and respond to independently produced models and projections could also consume substantial time and energy.
- *Is standardization necessary?* A related question was whether a requirement to publish data might necessitate standards for variables that must be included, data structures, and forms of publication. Some argued that this standardization would be prohibitively expensive. Advocates of data availability replied that while it would be valuable to have more standardization, there is no reason why MPOs can't simply provide access to their data files. They noted that MPOs have opposed any types of standardization that would facilitate performance comparisons.
- *Access to models* was also seen as an important issue, but much more difficult to address, since the models in widest use are in the private domain. One national non-profit organization noted that they had raised the funds necessary to purchase all of the major models, but still couldn't get the data they needed from the MPOs.

Models for advocacy

Several participants noted that modelers lack clear guidance for how they should behave in practice.

- *Planning vs. Law.* One participant observed that we teach planners/modelers that they have a responsibility to the truth; whereas lawyers' responsibilities are to their clients. Don't planners also have a responsibility to their clients? We're not necessarily giving future planners a clear message about where their responsibilities lie. Another responded that lawyers believe that the truth is revealed through a process of argumentation and discourse. The problem is that planners lack rules for how advocacy may be conducted. Lawyers do have very clear rules, as well as enforcement mechanisms to ensure that they are followed.
- *Roles of the planner/modeler.* Unfortunately, our educational institutions do not prepare practitioners well for the environments in which they will be working: they train them to be neutral analysts, even though this is impossible. Planners' and modelers' roles would be clearer if we didn't teach them that they know the truth. Most people come out of school wanting to be activist planners, but there aren't jobs for activist planners.
- *Picture is complex.* There are continually internal clashes among planners and analysts on the advocacy/rationality issue. It is naïve to blame the schools or professional societies for narrow adherence to one at the expense of the other, or to assume that establishing an ethical standard would change things.

Research Needs

Several participants suggested areas for future research:

- *Mode and route choice.* There is a particular need for more research on factors influencing mode and route choice. Model improvements in both of these areas are needed if models are to be helpful in developing innovative policies and projects (e.g. HOT lanes).
- *Simple models.* It would be very useful if somebody could develop a set of simplified models that could be used to illustrate and explore basic transportation principles. These could be used to educate public officials or community groups about some of the issues, options, and trade-offs.
- *Intergenerational considerations.* Can we develop a concept of the public interest and a process for planning that accounts for the important majority of stakeholders who haven't yet been born?
- *Alternatives to rational model of planning.* The rational-comprehensive model of decision-making is unworkable because it is impossible to consider all alternatives. But we ignore this problem and pretend we are following this model anyway, even though many types of alternatives are overlooked due to individual or institutional biases. How do we design plans and courses of action that allow the full range of alternatives to be considered? What are the problems with our institutions and decision-making processes that has prevented us from developing better transportation plans despite the tremendous resources that we have put into modeling and research?

Conference Outputs: An Ethical Standard?

Many participants expressed a desire for debate of these topics to continue beyond the end of the conference. Discussion centered around the feasibility of advancing a new ethical standard for transparency in modeling, as well as specific proposals for what that standard might be. Some of the opinions expressed during this discussion included:

- *Need for an ethical standard.* This conference should seek to advance an ethical standard for data and model transparency. We need to change the way most people think about these problems, and emphasizing this as an issue of professional ethics may help change the way this is viewed. We need to be specific about what changes need to occur and what their likely implications will be. Otherwise our recommendations will be ignored.
- *Need for leadership.* We have ethical obligations as the leaders in this field, but don't agree amongst ourselves. This is an important and fundamental discussion that we need to continue to have; at some point, we will need to take responsibility for making something happen. As leaders, we must set an example.
- *Role for professional societies.* Engineers come in two stripes. Most follow the rules rigidly and won't deviate from what is taught; but among transportation engineers, it seems that anything goes. There has been no movement by professional organizations to provide guidance for what the planning process should look like. But they should, if only out of self-interest: an analyst's findings cannot influence a decision-making process that exists simply to divide the spoils.
- *Guidance to the courts.* Under the current state of affairs, courts must make independent determinations of what is acceptable practice each time an MPO is sued. A standard of acceptable practice advanced by a professional organization or a research funding agency could provide useful guidance to the courts.
- *Actions beyond the conference.* Several fora and organizations were proposed through which these ideas about standards for acceptable practice might be brought to a larger audience. These included: professional societies, the Transportation Research Board, the National Asso-

ciation of Regional Councils, and/or an ongoing subcommittee of participants in this conference.

- *Advocacy network.* A related idea was starting a network of modelers who could serve as an ad-hoc advocacy organization that would challenge public-sector modelers to meet these ethical standards. Politicians exercise power by ignoring alternative analysis; a network of credible experts could play a useful role helping grassroots groups with some of the technical and political support they need. Some of the largest MPOs have the worst models and standards for openness.
- *Focus on data availability first.* It is important to have ethical standards in this area, and this indeed might take considerable time and effort. But this shouldn't hold us back from the very simple request to make data available.

Finally, participants discussed specific aspects of what an ethical standard might include, and drafted the following principles:

Asilomar Principles for Ethical Practice in Modeling and Forecasting

Modelers and forecasters have the following ethical responsibilities:

1. To present information and values informing the analysis process in a clear and open manner;
2. To sign and take responsibility for one's own published forecasts;
3. To submit one's analysis to independent peer review;
4. To conduct peer reviews in a constructive manner aimed at recommending specific improvements;
5. To document models and assumptions in a clear and publicly accessible manner;
6. To express results at an appropriate level of precision and to articulate uncertainty;
7. To conduct follow-up studies that evaluate forecasts and predictions over time;
8. To facilitate independent replication of model results by making full datasets and model setups available to the public;
9. To encourage independent generation and analysis of alternatives;
10. To develop and analyze alternatives representing the range of real choices and community values;
11. To provide adequate and timely opportunities for affected interests to influence the program of work throughout the planning process;
12. To make analytical tools available to all interest groups;
13. To promote a process of open and continuous innovation in the analysis of metropolitan systems;
14. To cooperate with and be respectful of all stakeholders;
15. To strive for integrity in one's professional conduct.

Panel 5

Future Innovations in Transportation Analysis

This session, moderated by Chuck Purvis of the Metropolitan Transportation Commission, focused on the state of the art and the practice in modeling, and what challenges and possibilities lie ahead. Moshe Ben-Akiva talked about efforts to incorporate insights from geography and the social sciences into travel behavior models. Mary Lynn Tischer described various efforts underway to develop a new generation of models, based on microsimulation and other approaches. Arnold Sherwood reflected on how models will need to adapt to keep up with the changing nature of air quality problems.

Introduction

Chuck Purvis, Metropolitan Transportation Commission

Exciting new activity-based modeling systems are under development or in use in such disparate locations as Portland, Honolulu, Boise, Stockholm and the Netherlands. While most practitioners are familiar with the various modeling techniques discussed so far at the conference, there are other methodologies like “satisficing” techniques and utility maximization that practitioners know less about and must take a wait-and-see approach to while research progresses.

On the other hand, a major challenge for MPOs in many areas of the country is finding well-trained staff to incorporate new research findings. The problem is simply one of too few technically proficient transportation planner/analysts willing to work for low starting salaries. Policy wonks are a dime a dozen, but a good transportation analyst must be *created*.

The profession’s modeling heritage is also its modeling future. Greig Harvey started developing STEP in 1977 as a cheaper alternative to the \$10,000 per model run UTPS “big model.” STEP is quick, cheap, and more accurate, since it works at the disaggregate individual level instead of at the aggregate zone-to-zone level. By the year 2008, we should have a disaggregate microsimulation system with point to point or parcel to parcel trip tables, a population synthesizer updated annually and ITS data used not only for monitoring transportation system performance, but for informing the choices of travelers in real time. Furthermore, I hope the future will bring continuous collection, or panel-based samples, of activity, time use and travel data. Ideally, these will serve as before-during-after databases for use in monitoring travel patterns and for estimation of travel behavior models. A final dream is that twenty years hence surveys will be of high quality and trip assignment methods will allow analysts to reasonably estimate the extent and duration of peak period congestion.

Behavioral Realism in Urban Transportation Planning Models

Moshe Ben-Akiva, Massachusetts Institute of Technology

In a 1985 article, Greig Harvey wrote, “there are enough positive examples of information use to suggest that decision makers would welcome better information, but are pessimistic about the ability of transportation professionals to provide it.” Towards increasing the capacity of the profession, Harvey went on to identify three areas that warrant and provide opportunities for innovation in travel demand forecasting: modeling methods, data and behavioral realism. This presentation deals with the last of these, and is based on a paper I co-authored with John Bowman, Scott Ramming and Joan Walker on incorporation of behavioral realism in transportation models.

Almost all travel demand models assume that the value of time is fixed. However, this simplification will tend to under estimate the demand for high-cost toll roads. Taking into account the fact that the value of travel time has a continuous distribution in the population has significant ex-

planatory power. The complexity of the work trip commute varies significantly by household structure and gender. So how should we represent this travel behavior in travel demand models?

The transportation modeling community recognizes the way to do this is by moving towards day schedule models that link tours along a time continuum. This is apparent by the evolution of travel demand models over the last twenty years. The first generation of discrete choice models, e.g., STEP, relied on an integrated trip-based framework which assumed a dependency between home-based work trips and other home-based trips. The second generation of discrete choice models, the framework of which was developed in the Netherlands, is tour-based. The most recent modeling idea is the activity-based framework that attempts to capture the activity travel schedule for the entire day. We have tested this new approach using travel behavior data from Boston, and were pleased when it was used in the Portland case that Keith Lawton discussed earlier.

Research on incorporating behavioral realism into modeling is moving in several directions. At MIT, we are working to extend the activity approach just discussed to mobility decisions, e.g., vehicle ownership and residential location. The focus of this work is to have activity accessibility, as opposed to trip accessibility, drive mobility decisions models. A second branch of continuing research attempts to use lifestyle factors as predictors of activity patterns. Household structure, economic status, work hours, and other factors have been found to be significant in explaining activity patterns.

Modelers must return to fundamentals by recognizing that choice involves processing information about the transportation network and that limited and imperfect information also impacts choices. This indicates a need for new approaches to reflect the heterogeneity of travelers' information and information processing capabilities. Toward this end, we at MIT have categorized levels of "network knowledge" and developed the following hypotheses concerning it.

- Network ability, experience and information consulted determine alternatives and variables considered during the choice process.
- Individual characteristics affect network ability, but may be hard to elicit.
- Responses to psychometric questions may help indicate network ability.

Advanced behavioral modeling techniques have been made operational in small, specialized models. The need now is to adapt them for application in large scale urban transportation models. This is complicated by the fundamental modeling problem of adequately representing a decision process that has infinitely many feasible outcomes in many dimensions. The key to solving it is simplification in a way that still produces valid results.

Large Scale Systems Modeling

Mary Lynn Tischer, Volpe National Transportation Systems Center

Three large scale system models currently in use or under development represent the type of model planning professionals will be working with in the future: TMS, TRANSIMS and HERS.

TMS (Traffic Management System) is a network of computers providing data and tools to support operational decision making for moving vehicles through the national air space. TMS generates an array of critical flight information such as schedules, plans, plan updates and progress reports. The tools for displaying these data include an aircraft/traffic situation display, list server, monitor and alert mechanism, delay manager, flight schedule monitor, airport configuration tool and an automatic demand resolution instrument. The key features of TMS are its user friendliness, near real-time functionality, scenario analysis capabilities and optimization strategies.

TRANSIMS is a travel demand model designed to capture an entire system of interest and also provide micro-level information. It builds on twenty years of analytical work and is composed of

four programs or modules. The first estimates activity-based travel demand from lifestyle factors using a synthetic population generator. The intermodal trip planning module identifies, over the course of a day, mode choice and employs minimum time path algorithms to assign trips. The traffic microsimulation component computes the movement of persons, goods and vehicles on the simulated network. The last sub-model identifies emissions and system impacts on the atmosphere. Like TMS, TRANSIMS has the capability to analyze alternatives. Also, like TMS, its data needs are enormous.

HERS is a large transportation model used by the U.S. Department of Transportation to prepare Condition and Performance reports for Congress. It calculates the condition and cost of each segment, estimates and compares the benefits of each action, chooses the strategy with the highest benefit-to-cost ratio and identifies the resultant cost. Alternatively, if there is an expenditure limit, the model calculates an overall best benefit based on that limit. HERS functions as a travel forecast, pavement management, speed change, accident, operating cost, maintenance cost and improvement cost model.

Five forces will affect modeling in the future:

- *Computer capability.* Advances in technology will allow modeling of more complex systems.
- *Better understanding of systems,* including the basic components of travel behavior, will increase the ability to provide more complex information.
- *Public expectations* will expand the role of modeling.
- *Democratization of data.* Wider availability will deepen and broaden policy debates.
- *Citizen experts.* The developing expertise of non-professionals will allow advocacy groups to explore issues once out of their purview.

Models of the future will be full-scale systems crafted from scratch or constructed by linking separate models together. They will be based on large relational databases requiring enormous computer capabilities, use individual level data and simulate systems. Finally, tomorrow's models will answer many new and varied policy questions, many of which require greater specificity and microanalysis.

In terms of future research, the President's National Science and Technology Council identified tools for transportation modeling, design and construction to assess system requirements, to plan and design system improvements, to evaluate alternative operational concepts and strategies, to estimate performance characteristics likely to result from innovations and to manage system operations among the national goals for federal science and technology investments. The Council's more detailed recommendations (e.g. understanding the economic, financial and institutional context for transportation) provide clues to how research dollars may be spent in the future.

The policy environment is also changing. Passage of the Government Performance and Results Act (GPRA) is indicative of this. GPRA expresses congressional intent to provide greater oversight on the expenditure of funds and to judge the effectiveness of monies spent by government. It specifically requires evaluation of agency performance in meeting their missions and an accounting of program funding. All transportation programs will be monitored and expenditures from the trust funds measured in terms of their success in meeting program goals.

Based upon the enhanced planning reviews conducted by FTA and FHWA to date, we know that ISTEA has increased the importance of technical analysis in formulating transportation policy and investment decisions. The reviews suggest that many MPOs are in the process of updating their models to "best-practice" standards. Ultimately, the test of whether models are improving relates both to whether transportation decisions are better and whether the debate is enhanced. Public understanding of alternative futures and how transportation decisions contribute to their

attainment are goals unto themselves. One role of models is to describe how that happens. However, as has been made clear throughout this symposium, although models are important, nothing beats common sense!

Future Issues in Air Quality and Mobility

Arnold Sherwood, Southern California Association of Governments

In the future, the linkage between travel behavior and air quality will substantially weaken because government and industry are improving air quality through technology and the use of alternate fuels. In light of this, what is needed to manage the air quality impacts of transportation that will remain?

- *Real-day emissions data sets for use in modeling air quality.* These will only become more important as time progresses.
- *Capabilities to model traffic incidents.* When models are validated there are traffic incidents embedded in the data that are not screened out properly.
- *Descriptions of acceleration and deceleration of vehicles.* This will increase in importance as more is learned about what contributes to air quality.
- *Consideration of terrain in transportation models.* If acceleration affects mobile emissions, then so does terrain.
- *Techniques to eliminate peak period overlaps in modeling.* By constraining to the peak all types of trips that either begin or end during the period, modelers over-congest the networks.
- *A better connection between segmented emissions and total trips.* Emissions are really derived from total trips. Currently modelers apply emission factors to segments for estimating emissions.
- *A strategy for addressing weekend travel.* It is now a real possibility that the worst air quality days in Metropolitan Los Angeles may begin to fall on weekends. If this happens, current analyses will be useless for evaluating policy choices.

The modeling issues emerging with regard to mobility are just as critical and complicated. For example, SCAG is considering truck lanes, high speed rail and demand responsive smart shuttles in developing its regional transportation plan. Unfortunately, SCAG does not have good data or good models to understand the impacts of these transportation alternatives. There are not even methods to fully integrate these choices into the existing models. Similarly, in contrast to state highway systems, arterials are not well described in the networks used currently.

It seems unlikely that the problems of modeling the interaction between land use and transportation can and will be solved anytime soon. It is, however, critical for professionals to fully understand this dynamic. Residential location is the weakness of the land use models at the current time. Obviously, choice of location involves more than a consideration of travel times. Planners can learn a great deal from marketers. They have a very good understanding of consumer needs and desires disaggregated by zip code. Their methods of analysis are substantially more advanced than ours.

Another important issue will be high-speed rail. It will have tremendous land use implications if it is built in the United States. For example, Barstow, which is 150 miles from Downtown Los Angeles, would be only 30 minutes away and could function as a suburb like Pasadena. More generally then, some of the choices made about infrastructure will be a big determinant of future research needs.

It seems possibly that pricing will be instituted in California and nationally, but through the back door. As advanced safety systems emerge and ITS comes into its own, standard equipment on mo-

tor vehicles will allow them to be easily monitored. At the same time, a scarcity of transportation infrastructure dollars will develop because of falling gasoline tax revenues from increased vehicle fuel efficiency and the growing popularity of alternative fuels. These two trends should converge and produce a natural demand for pricing in the future.

Discussion

The following issues were raised in the discussion that followed:

- *Plan before collecting data.* The profession should develop standards and before undertaking major data collection efforts. Otherwise, the chances will be low that the data collected will be particularly useful. The federal government often collects data indiscriminately, with the result that much of it is useless. Currently, there is a very problematic “buyer beware” situation.
- *More emphasis on sketch models.* More attention needs to be paid to the development of modeling techniques that can be applied in education and community involvement contexts. We also need to train a new cadre of professionals capable of doing this type of work.
- *Can we model supply instead of just demand?* There is some work on supply in the area of dynamic traffic assignment. The Urban Transportation Planning models usually use static assignment which is not adequate to represent congestion. At MIT, the work on dynamic traffic assignment methods involves simulation and is going forward at both a mesoscopic and microscopic level of description. There is similar work taking place at other institutions.
- *Modeling vs. forecasting.* Modeling is probably well taught in our institutions of higher learning. Unfortunately, the issues of forecasting such as bundling disparate sets of assumptions, are probably not. Hopefully, that problem will be remedied in time.

Conclusion

Interpretations and lessons for the future

In this final panel, Elizabeth Deakin and Mike Meyer reflected on conclusions reached during the course of the symposium.

Summing Up What Has Been Said

Elizabeth Deakin, University of California at Berkeley

Marty Wachs asked: Considering all its flaws, why do we bother with forecasting? It may be the best way we have to introduce some information into our decision-making about transportation and land development. It reflects deeply our values and is a reflection of mutual learning. On the other hand, doctored forecasts fall short of our own expectations for ourselves, and are a corruption of our intellectual capital.

Genevieve Giuliano said that we have to be modest in our thinking because of the constantly evolving trends that make it more difficult for us to look into the future. What she implied but left unsaid is that we don't have to be run over by these trends: we can perhaps do something to shape them.

Larry Dahms pointed out some of the reasons why we don't pay attention to models. One of these is that modeling frameworks typically cover only a portion of the issues that public officials must take into account. They also often ignore the possibility of reallocating costs and benefits. In addition, there is an institutional mismatch between modelers' ability to solve problems, and the policy levels under their organizations' control.

Keith Lawton and Keith Bartholomew gave an exciting example of how a public discourse over models can be built. The Portland experience is particularly interesting in that it started with conflict and ended with partnership. Through this process, organizations developed and became more responsive, responsible, and effective. As the models improved, they became better able to play an educative role.

The New York example presented by Therese Langer and Jeff Zupan offers a negative alternative: the region has not been able to improve its models or institutions in the public sector. But grassroots efforts have brought a positive approach: collaborative efforts to develop alternatives and challenge the public institutions to do a better job. This will be interesting to follow to see if it ultimately leads to capacity-building in the public sector.

Frank Koppelman reminded us that we need to be mindful of human and institutional preferences and humble about our understanding of them. We need to start thinking about strategies for taking uncertainty into account, and for protecting against unexpected consequences. Some important strategies include: peer review, access to information and methods, and consideration of multiple alternatives.

Michael Replogle discussed the need to cultivate a culture of planning. Using conflict effectively can be a way to build collaborative forums and a foundation for better planning. But we need to remember that lawyers are often more effective at managing conflict than engineers are; we need to learn to do a better job. Information and analysis can be a powerful and democratizing tool.

Geoffrey Gosling, Cliff Winston, and Daniel Brand all raised questions about how we adapt to changing technology and evolving modeling needs and applications. They are each using analysis tools to answer new questions about new policies and technologies. In this context, Edward Jordan observed that the ultimate issue is the integrity and plausibility of results, rather than their precision.

John Duve talked about how direct experience with demonstration projects can itself be a model or a learning process that improves our future modeling capacity. Steve Heminger reminded us that we

can learn from our failures, and that we need to think about public perceptions, ideologies, and effective communication in public debates.

Brian Taylor showed how complex equity and efficiency issues can be, using transit as his example. Fred Salvucci stressed the need for leadership in our efforts to get policymakers to do the right things. He also stressed the importance of being empathetic, and thinking about how people who are affected by a policy change will react to it. We need to do a better job of understanding people at the receiving end of our policies.

Moshe Ben-Akiva is expanding the scope of modeling beyond the traditional techniques found in civil engineering. He is now incorporating ideas from psychology and geography into his modeling work. We are increasingly linked with these fields and need to develop stronger understandings of them. This raises questions about where civil engineering education should be moving in the future.

Mary Lynn Tischer and Chuck Purvis emphasized that data quality is crucial. We have made progress in improving theories and models, but quality of data and access to it are limiting factors. Arnie Sherwood illustrated this point in discussing air quality analysis needs in Los Angeles.

The evening's conformity discussion led to issues of ethics. There is a tendency for conformity analyses to degenerate into exercises in adjusting assumptions and parameters to "pass a test" rather than to examine how alternative programs and projects might perform. One reason why conformity has become as complex as it has is the lack of response of transportation institutions to earlier federal mandates to incorporate environmental values into their decision-making. This raises broader questions about educative roles for modeling in planning and analysis.

Marvin Manheim's talk was an attempt to give us a meta-process for what we do as professionals, tying together information technologies into learning and decision-support systems. He reminds us that we are working within a larger context than the specifics of how to calibrate a particular model.

From this rich set of presentations, there are three ideas I would like to emphasize:

1. *What are the questions that modelers need to be asking?* How do the questions get generated? To what extent are we going to take responsibility for helping to identify questions and issues that need to be addressed in our regions, and exploring what their consequences might be? If we think that activity analysis is important, we need to explain to the agencies paying for model development why it should matter to them.
2. *Need to focus on institutional learning.* How do we make sure there is some institutional memory in organizations responsible for modeling? Are some institutional formats more conducive to learning? This is an area in which some useful research might be done.
3. *Need to pay more attention to the selection of alternatives.* As Britton Harris commented, we need to pay attention to process design since we can't possibly consider all alternatives. This is a process design question, not an optimization or technical question.

Greig had great fun with his work. He read extensively, and drew upon the work of many people. He believed that ideas should be spread around and shared, and tremendously enjoyed collaborating with many people on his numerous projects. He would have been excited by the topics we have discussed at this conference.

Some Common Threads

Mike Meyer, Georgia Institute of Technology

The topic and themes of this conference echoes a two-decade-old book, *Models in the Policy Process* (Martin Greenberger et al., 1976). This book notes that the “political context in which policy modeling is conducted makes it a strikingly different activity from the traditional modeling fundamental to scientific research.... The organizational framework in which policy models are developed and applied is also of key importance.”

This conference has noted that there are many different roles for models: providing information for decision making, reflecting our understanding of a system and its interdependencies, educating modelers themselves by enabling them to conduct experiments, enabling “what if...?” scenarios to be developed for policy makers, determining whether we are getting where we want to be (as is being done in Portland), providing credible assessments of where benefits have occurred, and serving as a form of communication.

Another theme was the mismatch that often occurs between modeling analysis and decision-making. For example, models being used for air quality analysis were not designed for that purpose. Policies are being developed simultaneously at multiple scales in many different decision-making environments; and models are serving many roles (regulatory, consensus-building, etc.), each of which has its own time scale and unique questions.

Common points of departure in our discussions about modeling and analysis are that they:

- Provide knowledge to decision making process and act as a form of communication.
- Can and should have important roles in major decisions.
- Have inherent uncertainties and value judgements that need to be acknowledged
- Are applied in different institutional contexts and scales of application
- Have difficulty effectively incorporating the exogenous trends and shocks inherent in our changing world. Using experts may be more effective than building these issues into models.
- Should lead or at least follow the broadening of policy concerns. Models need to respond to their constituencies, but they tend to be more reactive than proactive.
- Can democratize information and technology, which is good. But this creates special problems for institutions (e.g. MPOs) that are used to having a monopoly on this expertise.
- Are a necessary but not sufficient condition for ensuring that decisions rely on sound analysis.

Another interesting theme has been how to consider implementation within the planning process. There is a broad and interesting literature on implementation, which has evolved from descriptive to substantive to analytical to strategic in nature. We should be considering “implementation time given feasibility”: the level of difficulty of a given policy determines the amount of time necessary to put the policy in place. Informed leadership can reduce the time necessary to get things done.

Some issues that will be growing in importance in the future:

- *Methodology of planning*, including the steps involved in the full decision-making process.
- *Awareness of sustainability/environmental issues*.
- *Data quality*.
- *Distributive impacts/equity*, particularly the impacts on groups that are “left behind” by the policies that we implement in metropolitan regions.
- *Improved understanding of the individual choice process*, including how to incorporate it into models, and understanding how people think.
- *Evolution toward real-time planning*, creating stronger linkages between modeling and operations/systems management.

- *Model capacities vs. policy needs.* Need to find a balance between decision-making outstripping modeling capabilities and modeling complexity going beyond decision-making interest.
- *Communications and credibility.* Need to learn to get ideas across in a technology/information society in which “everyone is a traffic engineer.”
- *Intellectual cross-fertilization* is very important, but increasingly difficult in academia.

Integrity in analysis has been a central theme of this symposium. We need to learn to:

- Note uncertainties and assumptions honestly
- Acknowledge value-laden approaches
- Use common-sense checks
- Advocate what we believe in (based upon our analysis)
- Understand how to be effective in an institutional “mess”
- Live to fight another day... pick battles carefully. We need to acknowledge the constant struggle to balance practical considerations with ethical ones.

Several presenters in this conference used the metaphor of a “bridge” between policy making and technical analysis. But a bridge does not stand without strong foundations. In Greig’s case, those foundations were theory, experience, and integrity.

Final Comment

Fred Ducca, Federal Highway Administration

We need to identify and address the questions emerging on the horizon. They seem to be land use, sustainable development, intelligent transportation systems, environmental justice and equity, climate change, new vehicle technology, and vehicle operating mode. We need to step out of our narrow research fields, and design things comprehensively.

Another issue is funding: instead of just looking at how to get a slice of the pie, we need to try to expand it. If we want MPOs to do a better job, we need to think about how to get them more resources. Outreach is a major cost that is often overlooked. Researchers need to think about how better to disseminate the results of their work.

Much has been said about the need to improve data, but we also should be able to say when what we have is good enough. We can keep improving the quality of our data, but this won’t necessarily improve the accuracy or validity of our models. We need to expand the number of questions we can answer, not just the accuracy with which we answer old questions: this would provide a powerful incentive for people to adopt new models.

Speaker Biographies

Keith Bartholomew has recently become the Associate Director of the Wallace Stegner Center for Land, Resources and the Environment at the University of Utah College of Law. At the time of the conference, he was a staff attorney with 1000 Friends of Oregon, a land use advocacy and research non-profit organization in Portland. While at 1000 Friends, he directed “Making the Land Use, Transportation, Air Quality Connection” (LUTRAQ), an applied research project assessing the use of integrated land use/transportation planning as a tool to reduce the need for new highway facilities.

Moshe E. Ben-Akiva is the Edmund K. Turner Professor of Civil and Environmental Engineering at the Massachusetts Institute of Technology, and Director of the MIT Intelligent Transportation Systems Program. He has been working on travel behavior analysis since the late 1960’s and is widely recognized for his work on transportation demand modeling. He is currently leading the development of a dynamic traffic simulator and an ITS test laboratory. He is co-author of a textbook on the theory of discrete choice analysis and its application to travelers’ decisions.

Daniel Brand is Vice President and Director of Transportation Planning Practice at Charles River Associates in Boston. He has served as Chairman of the TRB committees on Passenger Demand Forecasting, New Transportation Systems and Technology, and Intelligent Transportation Systems. Before joining CRA in 1977, he was Undersecretary of the Massachusetts Department of Transportation, Associate Professor at Harvard University, and a Senior Lecturer at MIT.

Mark Brucker works on solving environmental problems associated with transportation in EPA’s San Francisco office. Has worked with issues of growth, growth patterns, environmental impacts and alternative approaches to managing growth since 1975. Main activity is promoting changes to national and local transportation policies to discourage driving and encourage transit, walking and bicycling. This also involves encouraging adoption of transportation policies that give priority to environmental protection and economic efficiency rather than building roads and rail lines that foster sprawl and auto dependence.

Michael Cameron is an economist and is the Transportation Program Manager with the Environmental Defense Fund in Oakland, California. He is author of EDF’s 1994 study Efficiency and Fairness on the Road: Strategies for Unsnarling Traffic in Southern California, and their 1991 study Transportation Efficiency: Tackling Southern California’s Air Pollution and Congestion. Before joining EDF, Mr. Cameron worked for the U.S. Senate, Select Committee on Indian Affairs.

Larry Dahms has been Executive Director of the Metropolitan Transportation Commission for 20 years. He serves a 19-member governing board which represents the nine counties and 100 cities of the San Francisco Bay Area. He is Chairman of the Board of Directors of the Eno Foundation for Transportation Inc., past Chairman of the Transportation Research Board Executive Committee, and a member of the Board of Directors of the Intelligent Transportation Society of America, which he chaired in 1994.

Elizabeth Deakin is Associate Professor of City and Regional Planning at the University of California, Berkeley. Her major areas of interest include transportation policy, planning and analysis; land use policy and planning; energy and environmental policy; legal and regulatory issues; and institutions and organizations. At the time of the symposium, she was Acting Director of the Institute of Urban and Regional Development at the University of California, Berkeley.

Frederick W. Ducca manages the Travel Model Improvement Program, a combined effort of the U.S. Department of Transportation and Environmental Protection Agency to improve travel forecasting procedures. He has nineteen year of professional experience in the areas of transportation planning and travel forecasting.

John L. Duve manages the San Diego region's Advanced Technologies and Intelligent Transportation Systems (ITS) planning activities. He has been a leader in the region's efforts to use pricing as a tool to better manage the efficiency of San Diego's Interstate 15 Express Lanes, the first and only national demonstration of the use of congestion pricing. He also chairs the California Alliance for Advanced Transportation Systems (CAATS) Deployment Council and Expert Panel.

Genevieve Giuliano is Professor at the School of Policy, Planning and Development at the University of Southern California. She is faculty fellow of the Lincoln Institute of Land Policy, and a member of the Editorial Boards of *Urban Studies*, *Transportation Research*, and *Journal of Transport Studies*. Her research interests include the relationships between land use and transportation, transportation policy evaluation, and impacts of information technology on transportation and travel behavior.

Geoffrey D. Gosling is a member of the research staff of the Institute of Transportation Studies at the University of California at Berkeley. He is currently serving as the program manager for the National Center of Excellence for Aviation Operations Research, a consortium of universities and industry organizations funded by the Federal Aviation Administration. Current research activities include aviation security and safety, airport ground access, advanced air traffic control systems and forecasting requirements for aviation systems planning.

Steve Heminger is Manager of Legislation and Public Affairs for the Metropolitan Transportation Commission. He directs MTC's state and federal legislative advocacy as well as its public outreach and information activities. Prior to joining MTC in 1993, Mr. Heminger was Vice President of Transportation for the Bay Area Council, a regional public policy group. He is a member of the Board of Directors of Californians for Better Transportation and the California Council of Governments Directors Association.

Edward Jordon is Vice Chairman of the California Commission on Inter City High Speed Rail Transportation, and a member of the California Transportation Commission. He was previously President of the American College in Bryn Mawr, Pennsylvania, and Chairman and Chief Executive Officer of Conrail.

Frank S. Koppelman is Professor of Civil Engineering and Transportation at Northwestern University where he is coordinator of the Transportation Program in the Department of Civil Engineering and Director of the Master of Science in Transportation Program in the Transportation Center. He is currently principal investigator of Northwestern University's participation in a multi-university research program to develop advanced models of traveler behavior under the auspices of the National Institute of Statistical Sciences.

Therese Langer is Staff Scientist at the Rutgers Environmental Law Clinic, a position she has held since 1991. In that time, she has concentrated primarily on transportation and air quality, working extensively on policy and technical issues in both area. She has developed and led projects for the Tri-State Transportation Campaign in the areas of freight movement, alternatives to highway capacity expansion, Clean Air Act implementation and transportation conformity, bicycle and pedestrian issues, and rail station access.

T. Keith Lawton is Assistant Director for Technical Services at the Portland Metro Transportation Planning Department. He has led the development of a comprehensive set of transportation models for use by all jurisdictions in the Portland area. These models have many innovative features including the explicit estimation of walk/bike trips, the consideration of density and mixed

use, and explicit inclusion of some urban design effects on travel mode choice and vehicle ownership choice.

Marvin L. Manheim is William A. Patterson Distinguished Professor of Transportation at the J.L. Kellogg Graduate School of Management, Northwestern University, with appointment in the McCormick School of Engineering and Applied Science, and the Transportation Center. His research is in the globalization of business, integrated logistics, strategic management, knowledge management, and computer support systems for human problem-solving. He is Founding Principal and Chairman of Cambridge Systematics, and author of *Fundamentals of Transportation Systems Analysis*.

Michael D. Meyer is Professor of Civil and Environmental Engineering, Director of the Transportation Research and Education Center, and Chair of the School of Civil and Environmental Engineering at the Georgia Institute of Technology. Previously, he was Director of Transportation Planning and Development for the Massachusetts DOT, and a professor in the Department of Civil Engineering at MIT. He has written over 120 technical articles and has authored or co-authored numerous texts on transportation planning and policy, including a college textbook on urban transportation planning.

Michael Replogle is Federal Transportation Director for the Environmental Defense Fund, where since 1992 he has worked to reduce growth in pollution from transportation, emphasizing travel demand management and planning strategies. He was a member of the Travel Model Improvement Program Review Panel, the TRB Expert Panel on the Effects of Expanded Highway Capacity, and staff to the Energy and Transportation Task Force of the President's Council on Sustainable Development. He is the founder and past President of the Institute for Transportation and Development Policy.

Fred Salvucci is Senior Lecturer in Civil Engineering at the Massachusetts Institute of Technology. He served as Secretary of Transportation for the Commonwealth of Massachusetts during 1983-1990, and transportation advisor to Boston Mayor Kevin White between 1975 and 1978. His current teaching interests are in Urban Transportation Planning, Institutional and Policy Analysis, and Public Transportation.

Arnold I. Sherwood is the Director of the Performance, Assessment and Implementation Department for the Southern California Association of Governments (SCAG). In this capacity he is responsible for management of the regional transportation improvement program, conformity, benchmarking, monitoring, and intergovernmental reviews programs performed at SCAG. Prior to joining the SCAG staff in 1975, he was an Assistant Professor of Physics at the University of Arizona.

Ann Stevens is a Bay Area consultant specializing in technology and travel demand, with interests in the history of science and technology. She is currently working as a software developer.

Brian D. Taylor is the Associate Director of the UCLA Institute of Transportation Studies and an Assistant Professor of Urban Planning in the School of Public Policy and Social Research. His current research is on the politics of transportation finance and planning, including the history of highway finance and the effect of public transit subsidy programs on system performance and social equity. He has also examined the relationships between transportation and urban form, including the effects of suburbanization on employment access for low-income workers.

Mary Lynn Tischer is Director of the Office of System and Economic Assessment with the Volpe National Transportation System Center where she oversees a large technical office that provides assistance on wide-ranging transportation issues relating to cost-benefit analysis, modeling, planning, forecasting, regulatory and industry analysis, for the U.S. Department of Transportation and for other federal, state, and local agencies. Previously, she was the Director of the Of-

Office of Policy Analysis, Evaluation, and Intergovernmental Relations with the Virginia Department of Transportation.

Martin Wachs is Director of the University of California Transportation Center at the University of California, Berkeley, where he also holds faculty appointments Professor of City and Regional Planning and of Civil and Environmental Engineering. Until July, 1996, he was Professor of Urban Planning and Director of the Institute of Transportation Studies at UCLA, where he served three times as head of the Urban Planning Program. Recently, his writings have dealt with the relationship between transportation, air quality and land use, and transportation finance.

Clifford Winston is Senior Fellow in the Economic Studies program of the Brookings Institution. He specializes in analysis of industrial organization, regulation, and transportation. Winston is co-editor of the annual microeconomics edition of Brookings Papers on Economic Activity. Prior to his fellowship at Brookings, he was Associate Professor in the transportation systems division of the Massachusetts Institute of Technology's Department of Civil Engineering.

Jeffrey M. Zupan is a transportation consultant with 35 years of experience and serves as Senior Fellow for Transportation for the New York Regional Plan Association. Mr. Zupan is co-author of three major books, *Urban Rail in America*, *Public Transportation and Land Use Policy*, and *Urban Space for Pedestrians*, and author of many reports and technical papers on a wide variety of transportation matters.

Participant Roster

Carlos Arce, NuStats International
Keith Bartholomew, 1000 Friends of Oregon
Moshe Ben-Akiva, Dept. of Civil & Environmental Engineering, Mass. Institute of Technology
Kiran Bhatt, KT Analytics
Alan Bowser, Automobile Club of Southern California
Mark Bradley, Mark Bradley Research & Consulting
Daniel Brand, Charles River Associates
P. Anthony Brinkman, Dept. of City & Regional Planning, University of California, Berkeley
Chris Brittle, Metropolitan Transportation Commission
Mark Brucker, U.S. Environmental Protection Agency
Anthony Bruzzone, Pacific Transit Management
Michael Cameron, Environmental Defense Fund
Lawrence Dahms, Metropolitan Transportation Commission
Elizabeth Deakin, Dept. of City & Regional Planning, University of California, Berkeley
Barbara Ditrich
Frederick Ducca, Federal Highway Administration
Pamela Durgin
John Duve, San Diego Association of Governments
Karen Frick, Metropolitan Transportation Commission
Lucy Garliauskas, Federal Highway Administration
David Gillen, Institute of Transportation Studies (ITS), University of California, Berkeley
Genevieve Giuliano, School of Policy, Planning & Development, University of Southern California
Todd Goldman, Dept. of City & Regional Planning, University of California, Berkeley
Jacqueline Golob, Jacqueline Golob Associates
Thomas Golob, ITS, University of California, Irvine
Geoffrey Gosling, ITS, Univ. of California, Berkeley
Kenneth Green, Reason Foundation
Bruce Griesenbeck, Sacramento Area Council of Governments
Peter Haas, Center for Neighborhood Technology
Susan Handy, Community and Regional Planning Program, University of Texas at Austin
Britton Harris, University of Pennsylvania
Steve Heminger, Metropolitan Transportation Commission
Madeleine Harmann, Santa Cruz County Regional Transportation Commission
Linda Howe, ITS, University of California, Berkeley
Robert Johnston, ITS, University of California, Davis
Edward Jordan, California Intercity High Speed Rail Commission
Dan Kirshner, Environmental Defense Fund
Frank Koppelman, Dept. of Civil Engineering, Northwestern University
Therese Langer, Rutgers Environmental Law Clinic
Keith Lawton, Portland Metro
Sherman Lewis, Dept. of Political Science, California State University, Hayward
William Loudon, DKS Associates
Marvin Manheim, Kellogg Graduate School of Management, Northwestern University
Michael Meyer, Dept. of Civil & Environmental Engineering, Georgia Institute of Technology
Eric Miller, Dept. of Civil Engineering, University of Toronto
Robert Noland, Environmental Protection Agency
Maren Outwater, Cambridge Systematics
Christian Peebles, AC Transit
Richard Pratt, Richard Pratt Associates, Inc.
Chuck Purvis, Metropolitan Transportation Commission
Donna Reid, ITS, University of California, Berkeley
David Reinke, Consultant
Michael Replogle, Environmental Defense Fund
Earl Ruitter, Cambridge Systematics
Fred Salvucci, Dept. of Civil & Environmental Engineering, Mass. Institute of Technology
Kathryn Sargeant, Environmental Protection Agency
Mark Schlappi, Maricopa Association of Governments
William Schroeer, Consultant
Samuel Seskin, Parsons-Brinkerhoff
Arnold Sherwood, Southern California Association of Governments
Mary Ann Sims, ITS, Univ. of California, Berkeley
Alex Skabardonis, ITS, Univ. of California, Berkeley
Howard Slavin, Caliper Software
Theresa Smith, Federal Highway Administration
David Souten
Daniel Sperling, ITS, University of California, Davis
Leigh Stametz, California Energy Commission
Ann Stevens, Consultant
Edward Sullivan, Dept. of Civil & Environmental Engineering, Cal Poly, San Luis Obispo
Brian Taylor, ITS, Univ. of California, Los Angeles
Mary Lynn Tischer, Volpe National Transportation Systems Center
Martin Wachs, ITS, University of California, Berkeley
Joan Walker, Dept. of Civil & Environmental Engineering, Mass. Institute of Technology
Melvin Webber, ITS, Univ. of California, Berkeley
Rachel Weinberger, Cambridge Systematics
Linda Wilshusen, Santa Cruz County Regional Transportation Commission
Richard Willson, California State Polytechnic University, Pomona
Clifford Winston, The Brookings Institution
Jeffrey Zupan, Regional Plan Association

In Memoriam: Greig Harvey 1950-1997

Greig Harvey was born in Norwich, Connecticut on December 10, 1950. His father was in the Air Force so he moved a lot as a young child. Later his father worked at the Educational Testing Service and Greig went to public schools in Princeton, New Jersey. Greig had one younger brother, Gary. Greig's mother died when he was thirteen. After Princeton High School, Greig went to MIT.

An important part of Greig's childhood were the summers. He spent half of each summer with relatives on Cape Cod and the other half with relatives in New Hampshire. Greig loved New Hampshire. The Harveys were from Hillsborough, New Hampshire and Greig's grandparents lived there. Greig, Gary, and their father, Phillip, built a small cabin on some family land near Hillsborough. Greig went to the cabin as often as he could, practically commuting to Cambridge during part of his time at MIT, refining his driving skills, which became legendary among his friends.

In 1982, Betty and Greig bought a decrepit farm with a very old house and barn in nearby East Washington. From then on they kept homes in Berkeley and New Hampshire, but it always seemed that Greig's home was Hillsborough. Greig's brother Gary lives there with his family, just a few miles away. During the last fifteen years, Betty and Greig had transformed the New Hampshire house and barn into a sprawling and welcoming home and high-tech office. They had planted an orchard and garden with apples, cherries, peaches, syrup maples, raspberries, and, one year, more yellow squash than anyone could possibly eat, leading to such experiments as squash cake. Greig went to New Hampshire every chance he got, sometimes even flying back just for the weekend when business or Betty's work at U.C. kept them away.

At MIT Greig studied civil engineering and political science, earning both a bachelor's and a master's degree. He became interesting in transportation, studying with such people as Moshe Ben-Akiva, Nigel Wilson, Dan Roos, and Marvin Manheim. Transportation issues appealed to both Greig's all-encompassing intellectual curiosity and his practical New Hampshire side. He saw transportation as a problem in governance and analysis, and area where you could always find a new angle – human psychology, artificial intelligence, physics. Almost anything he came across in his voracious reading was grist for the mill. On the practical side, he often expressed disbelief that academic institutions were not more interested in an activity that constituted such a large percentage of the United States' GNP. During MIT and just after, Greig worked as a research engineer. As an undergraduate, he did the computer programming for one of the first dial-a-ride services in the country.

Greig met Betty Deakin while they were both at MIT. They were there during the days of student unrest in the early 1970's. One semester MIT decided to send all of the students home early and cancel the rest of classes. Betty and Greig were in a class whose professor scheduled a last-minute final. Betty and Greig both decided to check all of the reading materials out of the library but



Betty got there first. Their partnership was formed when, in Greig's words, "We cut a deal." They were married in Cambridge on July 3, 1976.

Greig and Betty came west in the fall of 1976 when Greig entered the Ph.D. program in civil engineering at U.C. Berkeley, thinking he was headed for an academic career. Betty started the first Cambridge Systematics office on the West Coast. Eventually, of course, Greig emphasized consulting while Betty is on the faculty at U.C. Berkeley. Greig's wide interests and "big picture" focus wasn't a good fit with a normal Ph.D. program, but he felt he got a lot out of his study and research at U.C. He worked with Dan McFadden of the Economics Department, doing travel demand forecasting, and with Bill Garrison on "big picture" ideas. From 1980 to 1984, Greig taught at Stanford in a program called "Infrastructure Planning and Management" in the Department of Civil Engineering. He was a gifted teacher – whether in a class or one-to-one. He especially loved teaching a course in "Institutions in Engineering." In 1984, the Infrastructure Planning program was disbanded and Greig decided to focus full time on consulting. He and Betty and Alex Skabarodis formed the firm of DHS in 1987.

Family and work were Greig's life. On the family side, Betty and Greig's son Michael was born in 1980. Mike went everywhere with them. In the early 1980s, Betty was on the City of Berkeley Transportation Commission and Greig was a familiar sight carrying the baby Mike high on his shoulders when he went to pick up Betty after a late night meeting. More recently, it was Greig and Betty who went to pick up Mike after his basketball games in a Rockridge gym. In the past few years, Mike traveled the country and the world with his parents, but New Hampshire also seems like Mike's true home. The farm is a perfect place to grow up – woods to walk in and wood to chop, crawfish to catch, a pond for swimming, raccoons to battle for the fruit in the orchard. When Betty had a sabbatical from her position at Berkeley and the family stayed east for a year, Mike started school at Phillips Academy at Andover to be closer to his parents in New Hampshire.

Greig enjoyed his work so much that he seemed to be always playing. At the same time, it was vital to him that the work he did was ethical – both in the method and in the uses. He started with broad interests that continually expanded. Some of this recent work included air quality issues, travel demand forecasting, congestion pricing, ground access to airports, and transportation policy implications of local government decisions. Recently he was working on the development of modeling techniques that would allow for quick response but precise analysis, and that could be used in local and regional decision-making. For Greig, maintaining the highest ethical standards was always an issue in the work. He and Betty have written a manual on modeling practices for regional agencies that includes these ideas. Betty and Greig were truly partners in their work – doing some jobs together, bouncing ideas back and forth, and helping each other teach and advise students.

Greig died early on February 7, 1997 in Los Angeles. He had gone to L.A. to meet Betty, who was speaking at a conference on environmental issues. He had spent the previous evening talking with Betty and friends and having a good time.

This simple chronicle of some of the facts of Greig's life doesn't do justice to his extraordinary warmth and humor, his insatiable interest in new information and his infinite ideas on how old information might be viewed in a new light, his capacity for friendship and conversation, his enjoyment of each new day. As his friends, we can only acknowledge how much we miss him and will try to let the fires that burned so brightly in Greig stay alight in our lives.

Selected Greig Harvey Bibliography

Deakin, Elizabeth, Ann Rappaport, and Greig Harvey, "Transportation systems management: A review of current activities," Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge MA, 1976.

Harvey, Greig, "Travel profiles for workers in the Bay Area," Institute of Transportation Studies, University of California, Berkeley, February 1979.

Harvey, Greig, "Geographic distribution of work-related travel impacts in the Bay Area," Institute of Transportation Studies, University of California, Berkeley, April 1979.

Harvey, Greig, "Improved analytical support for urban transportation policy," Center for Transportation Policy Research, Institute of Transportation Studies, University of California, Berkeley, 1979.

Harvey, Greig, "STEP, Short-range Transportation Evaluation Program: Description and user's guide," June 1979.

Deakin, Elizabeth and Greig Harvey, "Critical factors in the implementation of transportation measures : memorandum prepared for the National Commission on Air Quality," Institute of Transportation Studies, University of California, Berkeley, August 1980.

Deakin, Elizabeth and Greig Harvey, "Policy options for the transportation-air quality process," Working Paper 80-18, Institute of Transportation Studies, University of California, Berkeley, Sept. 1980.

Deakin, Elizabeth, Greig Harvey, *et al.*, "A study of transportation systems, facilities, and control measures that contribute to achieving air quality goals: Final report to the National Commission on Air Quality," Research Report 81-3, Institute of Transportation Studies, University of California, 1981.

Harvey, Greig, "Exploratory analysis of the Baltimore travel data set," Working Paper 81-20, Institute of Transportation Studies, University of California, Berkeley, Summer 1981.

Harvey, Greig, "Passenger traffic forecasting models for the Los Angeles International Airport: A tutorial," Working Paper 83-1, Program in Infrastructure Planning and Management, Stanford University, Palo Alto, 1983.

de Mello, Victor Bandeira and Greig Harvey, "Energy consumption in the Brazilian transport sector: A cost function approach," Fourth World Conference on Transportation Research, Vancouver, May 1986.

Harvey, Greig, "Study of airport access mode choice," *Journal of Transportation Engineering*, v. 112, n. 5, September 1986, pp. 525-545.

Harvey, Greig, "Organizational and institutional knowledge in civil engineering," *Journal of Professional Issues in Engineering*, v. 113, n. 1, January 1987, pp. 46-65.

Harvey, Greig, "Airport choice in a multiple airport region," *Transportation Research A*, v. 21A, n. 6, November 1987, pp. 439-449.

Harvey, Greig, "ACCESS: Models of airport access and airport choice for the San Francisco Bay Region," Deakin, Harvey, Skabardonis, Inc., Berkeley, 1988.

Harvey, Greig, "Ground access to San Francisco International Airport," Deakin, Harvey, Skabardonis, Inc., Berkeley, 1988.

Harvey, Greig and Elizabeth Deakin, "Studies on transportation and air quality," 1989-1991.

Deakin, Elizabeth and Greig Harvey, "CO₂ emissions reductions from transportation and land use strategies: A case study of the San Francisco Bay Area," Paper prepared for the Peder Sather Symposium, October 1991.

Harvey, Greig and Elizabeth Deakin, "Transportation control measures for the San Francisco Bay Area: Analyses of effectiveness and costs," Deakin, Harvey, Skabardonis, Inc., Berkeley, October 1991.

Harvey, Greig and Elizabeth Deakin, "Applying pricing principles to congestion management: Summary and comment," Deakin, Harvey, Skabardonis, Inc., Berkeley, December 1991.

Harvey, Greig and Elizabeth Deakin, "Air quality and transportation planning: An assessment of recent developments," February 1992.

Harvey, Greig and Elizabeth Deakin, "A manual of regional transportation modeling practice for air quality analysis," National Association of Regional Councils, Washington D.C., July 1993.

Harvey, Greig and Elizabeth Deakin, "Description of the STEP analysis package," Deakin, Harvey, Skabardonis, Inc., Hillsborough NH, February 1996.

Deakin, Elizabeth and Greig Harvey, "Transportation pricing strategies for California: An assessment of congestion, emissions, energy and equity impacts: Final report," California Air Resources Board, Sacramento, November 1996.

Greig Harvey Memorial Fund

In honor of Greig Harvey's contributions to the field of transportation, a memorial fund has been established in his name. All contributions go toward fellowships for students at the University of California at Berkeley who are studying in the field of transportation. More than ten thousand dollars have already been contributed to this fund, which enables the fund to become a permanent endowment. We sincerely thank the many people who have contributed, and would welcome additional contributions that will enable the fund to grow and increase the benefits that will accrue to transportation students in the coming years. Contributions are tax deductible and receipts will be provided for tax purposes.

Checks may be made payable to the **Greig Harvey Memorial Fund** and mailed to:

Martin Wachs, Director
University of California Transportation Center
108 Naval Architecture Building
University of California, Berkeley
Berkeley, CA 94720-1720