Proceedings of the Sixth TRB Conference on the Application of Transportation Planning Methods

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This volume contains papers and abstracts presented during the Sixth TRB Conference on the Application of Transportation Planning Methods, held in Dearborn, Michigan, on 19-23 May 1997. The conference was organized and sponsored by the Transportation Planning Applications Committee (A1C07) of the Transportation Research Board. Additional sponsors included the Michigan Department of Transportation, Southeast Michigan Council of Governments, and the Ontario Ministry of Transportation. Richard Marshment of the University of Oklahoma served as Conference Chair.

The Transportation Research Board is a unit of the National Research Council, which serves as an independent advisor to the federal government on scientific and technical questions of national importance. The National Research Council, jointly administered by the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine, brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees.

Edited by Rick Donnelly and Julie Dunbar
December, 1997

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Abstract

The ISTEA changed the outlook for planning in dramatic ways. And there is much debate about what NEXTEA will bring or change. Changes bring challenges and opportunities. These produce many issues or planning challenges for the transportation professional today. For the profession to maintain its integrity and to advance, all involved in the planning and design of facilities need to become more aware of the broad issues which must be accommodated. These relate to more than the technical advancements. Some are philosophical, while others are procedural.

This paper addresses some specific important issues for the transportation professional. The intent is to stretch the professional thinking beyond parameters of technical matters to issues directed at arriving at consensus plans which can be implemented. Some of the issues and challenges addressed in this paper include maintaining the public trust, being comprehensive rather than exhaustive, creating a "level playing field" for the analysis of alternatives, separating "technical" from "political" decisions, recognizing financial competition, being "objective" in the analyses and in public meetings, identifying measures of effectiveness that can be measured, and developing a consensus.

This paper emphasizes the importance of working to develop consensus plans, for plan implementation is the goal. The transportation professional must be adept at recognizing the pertinent issues, addressing them, and making comprehensible explanations which can lead to sound decision-making by authorities. This requires the traditional transportation planning skills as well as the ability to work with citizen groups and government officials to build consensus and help make decisions.

ISTEA changed the outlook for planning in dramatic ways. And there is much debate about what ISTEA2 (or NexT or NewTea or whatever) will bring, or change. Changes bring challenges and opportunities. These produce many issues or planning challenges for the transportation professionals today. Perhaps ***change*** is today's greatest inevitability—technological, social, economic, and demographic change. Change can be viewed as either creating opportunity, or it can be viewed as a devastating influence upon individuals if it is ignored or unanticipated.

A 1996 issue of the *Professional Services Management Journal*[1] enumerated some changes shaping our profession. It was suggested that several forces are destined to change our profession forever. These include such items as FAX management, warp-speed service, working the 24-hour clock (due to global networks of offices), and producing mountains of data—more than any human can keep up with! But in our data driven society, the author points out that relationship-building is again emerging as the way to get ahead. Facilitators, rather than production oriented people, will be those who can make accomplishments that count. Looking backward it is easy to see how changes have driven us. But looking into tomorrow is a different story, and keen insight, anticipation, and preparation can be the difference between success and failure as we experience an increasingly complex and changing world. Technology is right there near the top of the list of rapid changes.

There are numerous planning issues for transportation professionals to face today and in the future. These range from technical to procedural to philosophical. The intent of this paper is to address some of these planning issues to encourage discussion, consideration, and action on the part of all professionals involved. To maintain our integrity as a profession, we must incorporate into our efforts an awareness of both technical details and the broad issues affecting transportation.

These topics are addressed from the author's perspective based on some 40 years of transportation planning experience; they do not necessarily reflect the opinions of the Transportation Research Board or other organizations.

TRB Overview—1996

In its *Annual Transportation Overview*[2], the Transportation Research Board noted several key observations. These included the facts that most of the NHS already exists, but most as 2-lane roads; that about half of the nation's urban freeways are operating at capacity during peak hours, and that each dollar invested in preventive pavement maintenance pays off with 3- to 4-fold future savings.

TRB also noted some areas in which more effective technical tools are needed for environmental studies. These included analysis of wetlands, visual quality, and socio-economic impacts. These suggest some wide-ranging issues rather than those focused solely on transportation.

For the profession to maintain its integrity and to advance in the coming years, those involved in the planning and design of facilities need to become more aware of the broad issues which must be accommodated. A priority goal should be to achieve "win/win" situations.

The intent herein is to address transportation *planning*. This is from the viewpoint of engineering and transportation planning. In addition, the intent is to focus on the *long range planning* aspects rather than the entirety of the subject. Of course, a discussion of the subject requires touching upon system planning, corridor planning, route location, and major investment studies although the latter is not the focus of this presentation.

In order to address this matter, this paper is organized into two sections along with some conclusions. These sections relate to the question of whether long range planning is worthwhile and to a few of the technical challenges for the profession.

Is Long Range Planning Worthwhile?

What does "long-range" planning mean to you? Long range planning as used in this paper refers to developing a master plan, or a schematic plan, for a transportation system or facility, while looking ahead some 20 to 25 years. This "look-ahead" includes population, land uses, and transportation demand.

The time frame can be somewhat variable, but the intent is to be long enough to avoid near-term overcrowding and functional inadequacy as well as to give a good indication of where one is headed, transportation-wise. One might also say the time frame should avoid being so long that one has no hope of achieving acceptable accuracy in projections.

Long range transportation planning is at the very leading edge where one identifies what transportation will be needed to serve future populations. It cannot fully answer all of the questions one might pose about the future (even regarding transportation). There will be "forecast errors".

Transportation facilities create one of many land use categories, but it can exert a strong influence on how the others develop. We certainly recognize the interconnectivity and feedback relationships between transportation planning and land use planning, and it behooves us to plan accordingly.

Does anyone (here) question that long range transportation planning is worthwhile? Or, perhaps that it serves a good purpose in guiding decisions on future growth and transportation service? Let's look at this from two viewpoints-one is philosophical and the other is from some surveys of the profession.

In 1991, this Transportation Research Board Committee considering transportation planning for small and medium sized areas developed information on this subject.[3] A survey of Metropolitan Planning Organizations addressed the question of the value of long range transportation planning in guiding community decisions. Conditions have changed since 1991, but this work still provides a good indicator for our purposes here.

Planning directors (or their designees) answered this from four viewpoints-the General Public, the Business Community, Public Officials, and Professional Staff. Overall, 90% of the professional staff surveyed indicated that the effort expended to develop and maintain a long range transportation plan was worthwhile to guide decision-making.

Here are some of the reasons MPO directors indicated as advantages:

- It forces a review of where we are and where we are going.
- Long range planning process helps screen out "odd ball" projects.
- With multiplicity of local governments in the area, one long range plan prevents the conflicts of each having its own plan.
- Some problems must be addressed on a long term basis to have a larger plan to guide short range TSM type planning, which is piecemeal.
- It is just the tool needed to justify right of way acquisition at the time of land development.

On the negative side of the coin, several "hindrances" to the planning process were noted. Most of the responses indicated that the work was ineffective because others were making the decisions or because the plans addressed the wrong topics. For example, some indicated that the long range plans only endorsed existing projects, and others mentioned that no one followed the plans which were adopted. These problems still exist for the professionals involved in long range planning, and they certainly suggest a direction for improving the process-more meaningful involvement by the public and by elected officials.

Some Technical Issues

There are technical issues and challenges produced by the changing times. Over a period of time, there will be new procedures and techniques to be addressed and to be incorporated into the study processes. However, for this presentation, let's look beyond such matters as how to run a big highway network on an outdated computer.

These procedures include those established by policy, such as the directives for Major Investment Studies and other aspects of ISTEA. They also include technical improvements such as are associated with land use models. In addition, there are new or modified planning concepts such as are associated with Environmental Justice, Livable Communities, Sustainable Communities, and Least Cost Planning. These are important topics too broad to be addressed in detail herein.

Over the past several decades there have been shifts in the public's perception of its needs. In reality, the relative needs for investment of public funds are constantly shifting. As professionals in transportation, we need to recognize these trends and to seek to overcome the public apathy currently directed towards the transportation industry. This also requires recognition of other societal needs which make demands on the same source of funds-the public. The matter of the National Debt will be with us for decades, at best.

As we seek to maintain professional integrity and the ability to guide decision making, there are some technical challenges which require attention. These include such matters as contending with the impacts of the "communications revolution", the information highway as it were, the proliferation of technology, and of the aging population in this country.

Whether we like it or not, the profession is involved in looking into the future as a normal course of action. To properly do so, one must keep an awareness of trends in society in order to address a changing world with changing needs. Transportation planning engineers need to become visionaries in the positive sense of employing sound discernment and unusually fine foresight in the planning process.[4]

For this presentation, three topics are noted in particular-knowing how much study is enough, maintaining objectivity, and accommodating those whom some might view as extremists.

Knowing How Much Study Is Enough

A continuing dilemma in long range planning is to investigate matters in sufficient detail without taking too much time and effort. One must quickly determine those matters which contain "fatal flaws" and should be discarded. The time and effort should be directed towards advancement of beneficial projects rather than towards making studies. One should give sufficient attention to the question at hand, but one should not evaluate beyond the accuracy possible at that point in time in the overall scheme of things.

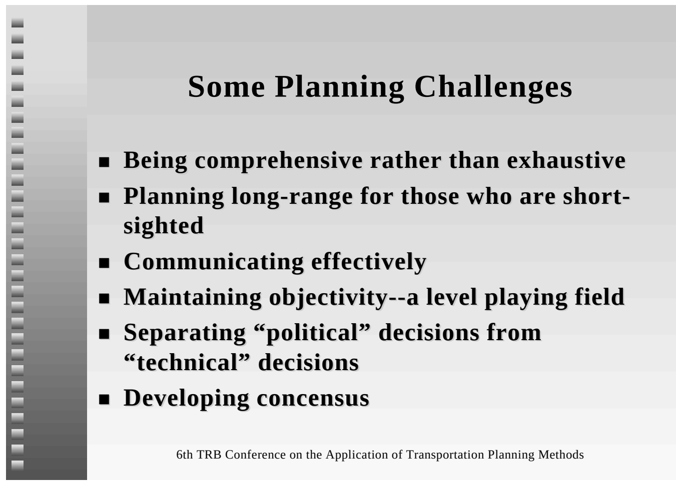
This requires a sound philosophy of approach for the various transportation planning analyses one must undertake. A large part of this philosophy is determined by federal, state, and local procedures, which continue to evolve.

For the long range planning endeavor, three specific guidelines come to mind:

- *Be comprehensive rather than exhaustive in the approach.* Comprehensive suggests considering all applicable factors to a sufficient degree. An exhaustive analysis, as used herein, means having studied an element to as full a degree as one is capable rather than to a degree commensurate with the process at hand. Even the “15 ISTEA Factors” require attention to detail from the viewpoint of controlling how much detail is needed.

Long range system planning should be followed by additional planning and design to address the many details for worthy projects. For example, “establishing a location” for a new, long range facility might mean a corridor two to five miles wide in outlying portions of urban areas during system planning. If there are significant issues to be addressed further, a major investment study could be appropriate at a later date to define the problem and potential solutions, while refinement of the location would take place in the route loca-tion/EIS phase of study.

- *Make allowances for the potential pitfalls.* Long range planning should give consideration to the “what ifs” and then make allowances for the unknowns rather than attempting to answer all questions. For example, one may not know the type of rail car or transit station that will be developed but can make cost allowances for several alternatives until later studies can produce more refined assessments.



  There are many pitfalls in long range planning associated with the uncertainties of the future. For many applications, the profession has developed highly refined (and useful) techniques utilizing mathematical models. The travel demand models are premier examples. However, the reality is that inputs to the models are fraught with weak data and future uncertainties. The predicted results are not likely to occur in detail—we only hope that they are adequate in gross.[5]

  Long range planning should make allowances for these pitfalls and shortcomings. Because of the great uncertainty inherent in all long term decisions, they should promote flexibility and omit details best decided on an incremental, short term basis.

- *Study what is vague more than what is interesting or easy to do.* The challenge in the long range planning process is to address the unknowns and the vague elements sufficiently to guide decision making. One should carefully anticipate the choices and issues that must be resolved as planning continues while recognizing that it is neither desirable nor necessary to decisions on all details. Thus, attention should be directed towards clarifying the vague areas sufficiently to proceed.

Spending too much effort on detailing the obvious and/or the more interesting concepts can be steps backwards for the overall effort. There are times when it is tempting to give only cursory attention to those items which are vague notions rather than to explore them sufficiently to understand the implications for the planning endeavor. On the other hand, there are times when, because one knows the subject, more than adequate effort is directed towards the popular and known concepts. For example, effort spent refining details of major street cross sections, or spent defining an unwarranted but popular facility, might be better spent addressing other questions or other concepts.

All three of these ideas are incorporated in some recent endeavors. For example, considerable attention is now being given to the development of techniques to properly address the interaction, or feedback relationships, of transportation and land use. There still seems to be a need to further develop the techniques for integrating transportation and land use planning.

Another aspect of knowing how much to study an element is the matter of defining roles for the various disciplines involved. The transportation planning engineer is charged with the need to have a broad understanding and perspective on many matters that go beyond “transportation”. These include land use planning, demand estimates (more than for transportation), environmental impact mitigation, and financing, to name a few. One does not need to be expert in all areas in order to give them proper weight and consideration using the counsel of others.

Certainly, different geographic areas and different times or circumstances will require different levels of study. Long range planning for transportation facilities should set a local stage for the future of the local area.

Maintaining Objectivity

In my mind, it is imperative that the professional not only maintain real objectivity but also portray that outlook to others. Everyone has some type of bias, thus this is a difficult goal for some to achieve. Objectivity as used herein means that one looks at all alternatives without prejudice and in a manner that permits true evaluation on the basis of the relative merits. Many see this as addressing the alternatives on “a level playing field” without having pre-judged some scenarios or alternatives as superior to others.

Perhaps the key to this is in establishing sound goals, objectives, criteria, and measures of effectiveness upon which to compare the alternatives. For example, in a multimodal corridor study one should establish criteria which fairly compare alternative modes of travel—e.g. they are reviewed using a level playing field.

Another aspect of maintaining objectivity is to recognize technical decisions versus other types of decisions. Usually, this is thought of as technical versus political. There may be sound technical reasons for selecting one particular alternative or direction of approach, but the decision may be made on the basis of a judgment of what is best for society (societal needs) rather than what is the best transportation solution technically.

It is incumbent upon the professional to identify those factors to be addressed technically and those factors to be left for others to interject into the process. One should also recognize that there can be a difference between interjecting other factors and simply having disagreement on the importance of certain criteria measures.

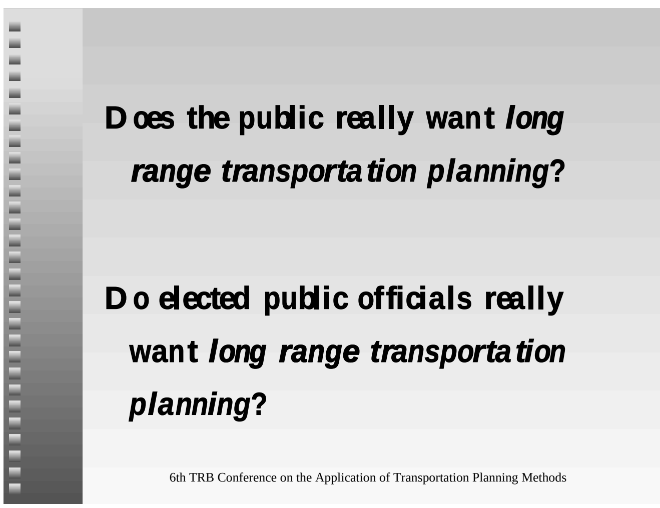
Accommodating Extremists

It is incumbent upon the profession to support what is best for the majority but doing so while continually keeping in mind the minority viewpoints. Who is out of step? It is not always a matter of the majority rules. Too often, one hears that the vocal minority-perhaps those who take the trouble to attend public hearings-dictate what is done rather than the majority.

The leader sets the pace, and the most knowledgeable should be the one to avoid the pitfalls. In long range planning, the professional responsible for the endeavor must work with individuals having varying interests, biases and understandings. There are likely to be those who hold what can be called an extremist's position on one or more matters.

Public involvement has been a part of long range transportation planning for decades. Rather, it has been recognized as a needed part of the endeavor. Some agencies and studies have had more meaningful participation than have others. Professionals should understand that the public involvement effort can help gain insight on what the real (and perceived) problems are, can be a starting point to establish support for the plan and to cause the plan to be implemented, and can be an educational experience. This latter item relates to both the public and to the professionals.

A critical element of this entire process is the development of consensus on what the transportation improvements should be. Where diverse interests and concerns are involved, there will be disagreement on the preferred solutions. However, a consensus is possible when approached adroitly with sensitive leadership.



Diverse outlooks are best resolved by up-front, open meetings and with meaningful discussion by the participants—not by lectures. Real discussion of issues must highlight areas of agreement and address the underlying reasons for areas of disagreement. Meeting groups must be small enough to permit thorough discussion, and results must be reported fairly to the larger groups and the eventual decision makers. Only then can the concerns be properly addressed. This also is best accomplished with not only leaders who are objective and have no bias but also those whom are perceived by the participants as being objective and having no study bias. The full study team of professionals must believe in approaching the entire process giving full consideration to all outlooks on a "level playing field", and this attitude must prevail throughout the process for true success in the long term.

Recognition also must be given to the fact that this or any similar process may not be able to achieve 100% agreement among the participants on all recommendations. This is certainly the desirable goal, with the primary objective being to create a win-win situation for all.

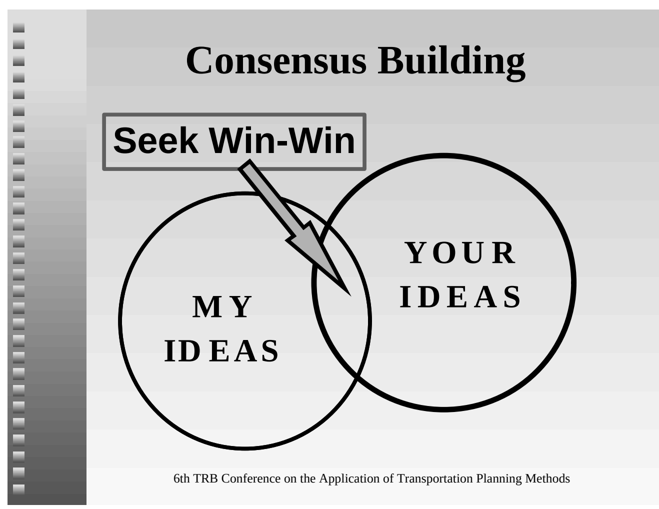
With these concepts in mind, one realizes that there almost always will be those who hold positions which can best be described as extreme. These extremists should be anticipated and should be given due respect while proceeding with the endeavor at hand.

Does the public really want *long range transportation planning*? Do elected public officials really want *long range transportation planning*? That is, do they really want to be told what is needed (long term) and how much it will cost and how to pay for it? There are experiences to support both "yes" and "no" answers. At the heart of the negativism here, one is likely to find problems with financing, involvement, trust and distrust of the process, and the relative importance of transportation.

Philosophically speaking, there are those who appreciate the need for looking and thinking long term rather than seeking near term satisfaction. The profession must push itself and others to look and to think and to plan for a longer term than now seems to be popular. When funding is inadequate, the implementation program should be adjusted within the long term plan—and adequate funding to meet needs should be pursued.

Long range system planning needs to focus more on planning and less on details (which very often cannot be foreseen with any accuracy). The role of long range system planning is to anticipate the issues and choices that must be resolved as planning continues and to devise tentative (or preliminary) decisions on logical sequencing of improvements to meet needs over the years. This sequencing of improvements should be a guideline as to desirable staging of the system implementation based on a consideration of the potential outcomes (both positive and negative) from these choices. This sequencing should be done while recognizing that it is not necessary nor desirable to make a final decision about the far future—leave future decisions open until more and better information is available. In other words, incorporate future flexibility into the long range plan.

However, there are many who will start from the outlooks that there are more pressing needs of society than for transportation, that they do not want to be disturbed (NIMBY), and/or that they want to delay the decision until someone else has to face the problems. These are viewpoints which must be addressed by the profession.



There are circumstances when citizens are more concerned about their individual property values than they are about the needs of society. There are those who will correctly assess the impact of a transportation facility, and there are those who will err. There are times when leaders will be concerned with avoiding conflicts or divisive decisions.

For the transportation profession to maintain its integrity, the transportation professionals must be adept at addressing these issues, among others. We need to find “win/win” situations.

A couple of guidelines seem most pertinent. The process should attempt to arrive at consensus on numerous items and, as has been mentioned, this involves an educational experience for all. This requires both a diplomatic touch and a firmness at times. Perhaps one key is to insure that early consensus is reached on procedures and level of detail that can be addressed in the study. For example, in setting study criteria, measures of effectiveness which can actually be measured in the study are a necessity. One technique here is to recognize those items or measures which must be addressed in later, more detailed studies *if the decision is made to adopt an improvement program or to carry it forward*.

Hostile situations are likely to develop when spirited dialog evolves. This is especially true when there is a mix of opinions and outlooks. The transportation planning profession must endeavor to address erroneous conclusions with correct information while avoiding the direct confrontation and showdown that can be so tempting. Usually, differences of opinion can be controlled and used to advantage by re-directing them to specific circumstances to which each might apply. In other words, by establishing which criteria apply to which position. Rather than take sides, the professional should illustrate applicability and facilitate discussion.

The transportation profession is deeply involved in looking into the future. We must be visionaries as well as practical planners. All planning is subject to periodic update in order to adjust for changes. On the other hand, one should have an adopted plan that is being used to guide development and decision making.

Everyone cannot be satisfied fully by what is done in the public's interest, but we can strive for "win/win" situations. Some recent experiences and some strategies for effective public participation are provided in the FTA Policy Statement, *Working Together on Transportation Planning: An Approach to Collaborative Decision Making*.[6]

For the transportation profession to maintain its integrity, the transportation professionals must be adept at addressing these issues, among others.

Some Conclusions

Professionals in transportation planning have more challenging issues than the rapidly expanding arena of technical processes. There are issues related to placing transportation into the entire fabric of society, and there is a growing challenge to be perceived by the public as being professional and fair. These are all important.

Those involved in long range transportation planning have some added challenges. They must push not only themselves but also others to look and think longer term than is currently popular. Immediate satisfaction, current year economy, one-term perspectives, "not in my back yard", and "not on my watch" may be very appealing to some. But the charge to the profession is to insure that in the grand scheme of things the general public is served by what is in its best interest.

How can the transportation profession help determine what is in the public's best interest? Certainly it requires an awareness of what the public needs in addition to transportation service, but it also requires an awareness of what the public *believes* that it needs. Perception is closer to reality than many might believe. Much of what is done today addresses these ideas. Some needs improvement.

Here are some suggestions for the significant planning challenges to professionals in long range planning:

- To be comprehensive rather than exhaustive in analysis approach.
- To make technical data and comparisons easy to understand (comprehensible).
- To maintain objectivity in identifying and analyzing alternatives.
- To provide safeguards for those who are short-sighted by looking sufficiently far ahead—i.e. long range.
- To accommodate extreme viewpoints while working diligently towards sound conclusions and decisions.

- To learn the art of developing consensus, or “win/win” situations.

These are important items in the development of study programs for long range planning projects. The availability of enhanced computer equipment and techniques permit the profession to both study and illustrate many matters which previously were difficult to explain to citizen and other groups. The transportation profession must be adept at recognizing the pertinent issues of a technical nature as well as of a decision-making nature. These need to be addressed as a matter of course along with making comprehensible explanations which can lead to sound decision making.

Notes

1. Stasiowski, Frank. 1996. “10 Forces Shaping Our Profession”. *Professional Services Management Journal*, Volume 23, No. 1, January 1996.
2. *TR News*, Transportation Research Board, National Research Council, Number 186, September-October, 1996, page 11.
3. Guyton, Joseph W. 1991. “Long Range Transportation Planning, a Troubled Process”. *Proceedings*, Transportation Research Board 3rd National Conference, Transportation Planning for Small and Medium Sized Communities, TRB Committee A1D05, Burlington, VT, (October).
4. See also comments by the author in “Long Range Transportation Planning for a New Era”, *Issue Papers*, Institute of Transportation Engineers International Conference, Monterey, California, 1992, page 77.
5. See also discussion in Chapter 3, “The Reality: Change Cannot Be Predicted with Certainty”, *A New Strategic Urban Transportation Planning Process*, Center for Urban Transportation Research, University of South Florida, June 1995.
6. US Department of Transportation. 1995. *Working Together on Transportation Planning: An Approach to Collaborative Decision Making*, an FTA Policy Paper, (May).

Prescribing The Future, Not Predicting the Future: Are Our Planning Methods Up to the Challenge?

Steven E. Polzin, University of South Florida

Preface

This paper was written as a speech for the opening session of the Sixth Conference on the Application of Transportation Planning Methods. Accordingly, it is written in first person and reads like a speech rather than a traditional research paper. The content has been modified slightly from the speech text to clarify or elaborate on certain issues and subsection headings have been added to increase the readability.

Good Morning, I appreciate the opportunity to share with you some of my perceptions and ideas regarding transportation planning and the challenges that will confront us as we are tasked with building that often-talked-about bridge to the future. I have been interested in the effectiveness of planning since 1976 when I submitted a dissertation proposal to evaluate the effectiveness of transportation planning. I persevered, finishing that task some ten years later and have enjoyed reflecting on the effectiveness of the profession at regular intervals.

In preparing for this talk I felt that I should have a good joke to tell. So, being a contemporary planner, I logged on to the web and typed the key words “Transportation Jokes” into my favorite search engine. I got back an alphabetized list of projects — Boston central artery project, channel tunnel, Denver airport, Detroit people mover, Dulles toll road extension — I decided that continuing with that list would offend my whole audience, so I changed my key words and found a story about three planners and three engineers.

Three planners were in line behind three engineers waiting to buy a train ticket for a commuter rail trip. The three engineers only bought one ticket and the planners were intrigued and followed the engineers on to the train. When the conductor came into their car collecting tickets, the three engineers went into the next car and entered the restroom. When the conductor reached that car he noticed the occupied sign and knocked on the door. One of the engineers handed out the ticket and the conductor went on.

Later that same day these two groups again arrived at the station at the same time for their return trip. The planners were in line first and were a bit haughty as they asked for a single ticket. They noticed that the engineers didn’t ask for any tickets and were perplexed, but continued on. When the conductor entered their car the planners quickly went to the next car and entered the rest room. The engineers followed a few moments latter. Pausing a moment, one of the engineers knocked on the restroom door and said “Conductor, ticket please.”

Disclaimer

Many of my comments in this talk will relate to public transportation, not because I think that public transportation has done a particularly good, or particularly bad job in planning, but rather because that is the area of planning where the majority of my experience exists. It is also an area that epitomizes many of the critical issues facing the transportation planning profession.

Most of what I say today are things that I feel quite strongly about, but some issues are raised primarily to stir discussion. So don't hold me accountable or ask me to defend everything I say. And, these ideas are certainly not reflecting the views of any of my clients or for that matter, many of my peers.

The focus of these comments will be on what I feel are the challenges ahead of us as transportation planning professionals. Accordingly, it may be perceived as somewhat critical of current practice as it notes areas where I believe we need to do a better job.

But, rest assured, I do believe that — sometimes in spite of ourselves — the transportation planning community has in fact done a very commendable job. We do have fantastic levels of very affordable mobility for the vast majority of the population. We have been responsive to social changes and trends. We lead the way in addressing the needs of the disabled community and in utilizing all manner of public participation in planning and decision-making for transportation infrastructure and services.

We are making progress in incorporating new technologies and we clearly have made great headway in addressing environmental and energy efficiency issues. Safety has improved dramatically. Roads do connect across political boundaries and sometimes bus routes do too. We export our technical expertise in planning, design, and technology and we have done a good job in developing a more interdisciplinary and diverse workforce over the past few decades.

We do invest in research, though not as much as some of us would like to see. Transportation costs are not negatively impacting our international competitiveness, and the condition of our transportation facilities is actually improving by many measures. We should celebrate these successes and perhaps even learn some lessons from them.

Key Frustrations

In spite of these successes, there seems to exist within the profession some key frustrations that keep us from taking pleasure in our accomplishments. First, I sense we collectively feel that we are falling farther behind. We often talk about transportation needs grossly exceeding resources. It's easy to attribute our good fortune today, not to the recent success of planners, but rather, to the prior generation of transportation professionals and decision makers who perhaps were more willing to make investments and hard choices.

Imminent gridlock is often referenced in local transportation plans, and numerous studies show huge gaps between needs and resources. The data all suggest that in terms of infrastructure investment per person, per vehicle mile of travel or per licensed driver, we are clearly not keeping pace. We are consuming our surplus capacity and cutting our reserve capacity very short. In the past, our transportation investments often focused on connecting points on a map and providing accessibility. With that task mostly behind us, we are now principally focused on providing capacity. Yet, we haven't made much headway in convincing the public of these needs.

There seems to be a significant disconnect between the planning profession's perceptions of need and those of the public. When we are done calibrating our demand models, we may have to calibrate our perceptions of need to more closely correspond to those of the taxpayers and voters. Perhaps this disconnect is a result of our inability to convince the public of the consequences of consuming the surplus capacity in our transportation networks. Perhaps we have raised the specter of gridlock one too many times. We have been threatening communities with imminent gridlock for decades and yet, average travel speed for most trips has improved. Perhaps it is the habit we have of talking about how volumes on roadways are 50% or 100% greater than what they were designed for. We cannot put two gallons of water in a one gallon bottle, yet, we in transportation have a convention that indicates most of our urban highway facilities are operating over their capacity. Little wonder the public may be confused or suspicious.

While we are often advocating increased capacity, we are slow to recognize that one of the virtues of crowded roadways and ten-hour peak periods is that our infrastructure investments are being productively used. If we were a private sector toll road operator we would not be complaining about our roads operating at a volume capacity ratio greater than one. We also often fail to account for how adaptable the public is in ensuring that gridlock never really arrives. “The sky is falling!” warnings will not help if we are not right.

In addition to this disconnect between the planners’ and the public’s perception of need, the second major concern that I believe confronts many transportation planners is a feeling of guilt, or at least nervousness, regarding the environmental or quality of life consequences of our transportation system. Even the most ardent highway advocate, or advocate of personal freedom of choice, has to feel some uneasiness when faced with the vision of perpetual ribbons of asphalt clogged with cars, lined by businesses surrounded by parking lots, noisily nestled under a noticeable brown haze in the sky.

There is, perhaps, a realization that there is not the space or the resources for our transportation behaviors to be adopted by the developing world and perhaps not the resources to enable us to continue down this same path for a second century of the internal combustion engine dominated travel. Yet, building twenty miles of light rail in every urban area with at least a million people, prefacing every plan with the word intermodal, talking about a balanced system, or even spending 20 percent of any new transportation trust fund revenues on public transportation services for the two percent of the public who chooses transit, may be doing little more than making us feel better and consuming scarce transportation investment dollars.

Other Perspectives on the Future

This conference is not alone in reflecting on the future of the transportation planning profession. Before addressing specific characteristics of our planning practices I would like to share with you a few thoughts that have influenced my thinking about the current status and the future or our profession. I would highly recommend four different items for your reading list.

First, looking back, I reviewed a speech written for a 1961 ASCE Planning Conference by a fellow named Wilbur Smith. This paper, titled Urban Transportation Tasks of the Future, outlines the perceived challenges facing our profession at that time. After numerically characterizing development and transportation trends, the authors says:

> Despite significant strides in technology, the continuing expansion of the American urban area has made the daily movement of goods and people a difficult and complex problem. ...The transportation plan of every urban area must take into account the desires of individuals. At the same time, it must deal with the abilities of individuals to pay for the level of services they desire and with both the abilities and responsibilities of government to provide or assist in providing basic components of each part of the urban transportation system.

Wilbur Smith
Urban Transportation Tasks of the Future, 1961

It is interesting how true that quote remains today.

In a similar vein, I reviewed another 36 year old publication. This was from Mass Transit magazine. The cover had an artist's rending of the Bay Area Rapid Transit system on it. Most intriguing, however, was an ad in the magazine by General Electric. The top half of the ad was a rendering of an intermodal station complete with a collection of various modes logically laid out to enhance transferability. The accompanying text outlined a statement that would need little editing to fit into most of today's transportation plans.

> For Commuters in thousands of towns and villages that surround America's traffic choked cities, travel in 1970 will be fast and convenient — if planning for coordinated metro transportation begins now. Improved and expanded commuter rail service is the key to better metropolitan transportation of the future. Millions of dollars will be saved if action is taken now. ... Before all these improvements can came about, commuter rail and rapid transportation must be integrated into a single, metropolitan-wide transportation system.

Mass Transit Magazine, 1961

The third item I would recommend is an unpublished paper prepared by Manuel Padron for an American Public Transit Association Operations Planning Conference a few years ago. Titled,"Impacts of Changing Demographics on Transit Planning," this paper is a particularly insightful review of the challenges we face today. It evidences a transit professional's frustration with the extreme challenge we have in making transit effective in light of the unrelenting and extremely powerful forces of suburbanization and decentralization. After elaborating on the difficulties of designing transit services for suburb to suburb trips, Mr. Padron said,

> Under these circumstances, what can we, as transit and transportation planners do? I wish I could tell you, in all sincerity, that we are facing "new challenges and opportunities", to quote the familiar phrase. What it really means is: I'll be dammed if I know what we can do.

Manuel Padron,
Impacts of Changing Demographics on Transit Planning

Finally, in preparing these thoughts, I reviewed a book that looks to the future. The short book, *Avoiding the Collision of Cities and Cars: Urban Transportation Policy for the Twenty-first Century,* is authored by Elmer Johnson, and based on a study sponsored by the American Academy of Arts and Sciences in cooperation with the Aspen Institute. It was published in September 1993. This particular book outlines a series of policy initiatives designed to provide a road map for helping overcome the social costs of our current auto dominated transportation system. It is well researched, reasoned, pragmatic and outlines a series of solutions to our transportation problems that few of us spend much time thinking about.

> We, the participants, believe that our recommended long-term strategies are still achievable in a democratic society, but only if they are preceded by pricing and other habit-changing strategies that confront people with the unpriced or underpriced cost of urban vehicle travel and the importance of new norms of social behavior.

Elmer Johnson
Urban Transportation Policy for the Twenty-first Century, 1993

This book certainly suggests a new set of skill requirements and challenges await the transportation planner.

So What Does this Mean?

So what does all this have to do with how we go about planning now for our future? Have we made any progress in the past 30 years? Are we making progress toward a better future? Have we figured out a way to overcome the negative externalities of single occupant vehicles (SOVs) or found attractive alternatives to them? While the above references no doubt raise a number of issues concerning how we do our planning, the remainder of this discussion is focused on some of the key issues that I feel confront us today. It will concentrate on three main questions.

- First, has the goal set for transportation planning gotten so broad as to suggest a need for a radical new model of planning, funding and decision-making for urban transportation?
- Second, are we quickly moving from an era where we focused on predicting the future to one where we appear to be more interested in prescribing the future. And, if so, does this require a fundamental rethinking of how we go about doing planning? and,
- Third, does the planning environment that we have helped create facilitate an objective information-based decision process? Or have we replaced analysis with advocacy?

The Broad Based Goal Set

I'd like to start by challenging one of the basic premises fundamental to the planning process as we are applying it today.

I believe that the single biggest challenge we face as a profession may be that we have let our goal-set get so big that we may be losing site of our mission and that we may be creating an unwieldy planning process. As each of you know, the planning process consists of a series of steps from problem definition and goal setting, continuing through the development of alternatives to the evaluation of alternatives to a recommendation, decision and implementation phase. We can add some extra steps, acknowledge feedback loops or emphasize component activities such as public participation, but nonetheless, planning applies a time honored problem solving process.

The set of goals we are dealing with for transportation has gotten extremely broad. We have simply taken the maxim that "transportation affects everything" to the extreme, and we now want to capture all those interactions in our planning and decision-making structure. We no longer restrict our mission to providing safe, cost effective and affordable transportation capacity, we are now attempting to right many of the wrongs in society via transportation investments. Indeed as a culture advances it is common to embrace a larger set of interests and concerns, but if we do that, then we need to do it very carefully.

Today's planning efforts include goals as far ranging as ensuring social equity, restoring a sense of community, enhancing quality of life and neighborhoods, providing jobs, and reducing the national balance of trade deficit to assuring the highest degrees of safety and security in our travel. Over time, the planning process has adapted to the growing list of goals by attempting to expand the evaluation processes and the planning methods directed towards providing information for decision makers that address this broader range of factors.

This enlarged goal set has some important implications for our planning process.

Let me note four specific challenges it creates.

1. It pushes us into subject matters that we are not necessarily experts in, and in some instances no one else is either.
2. It substantially increases the number of players in the planning/decision-making process.
3. It suggests that the range of choices for solving these multifaceted problems should extend beyond just transportation investments.
4. It suggests that the decision-making forum for transportation projects should be general purpose governments whose responsibilities cover the full range of issues often implicitly addressed by the transportation proposal. It may also suggest that the funding source for transportation projects be a broad mix of resources from sources whose responsibilities include attaining the full set of goals being addressed by the investment.

Let me address these one at a time. **First**, let's review the profession's expertise in evaluating the impacts of transportation investments for some of the goals that we now take very seriously. Take, for example, the area of economic impacts from transportation investments. While it has long been understood that a good transportation system was an integral part of a strong economy, we have gone far beyond that. We are now carrying out economic impact studies for individual projects. The state of the art for this type of analysis is evolving quickly. We used to simply apply multipliers times the spending for the project and claim some rather dramatic impacts. Indeed the merits of the project were irrelevant. We could build a subway system in a corn field in Iowa and still claim tremendous economic impacts even if the only passengers were a small group of old ball players.

Taking this logic to the extreme, if we had cost overruns, we had even greater positive economic impacts by virtue of the multiplier effect. If I invented a matter transporter ala Star Trek and sold it for $19.95 on late night TV, it presumable would have next to no economic impact since it wouldn't be creating large numbers of construction and operating jobs.

Not long afterwards we realized that net new money brought into a region was relevant in assessing economic impacts. In this scenario of evaluation, if I build a transit project with discretionary money, supposedly new money to the region, I could show a significant economic impact. If I built that same facility with local funds or formula funds, the economic impacts would be lower. Pork barrel projects have a high economic impact and formula or locally funded projects don't.

In this process of determining economic impacts we can have a high speed rail project claiming as an economic savings the reduced need to expand airports while at the same time on the other side of town we can have another study taking place that shows the economic benefits of expanded airport capacity. It is little wonder that we might be confusing the decision makers and perhaps misleading ourselves and the public.

Another area where we are struggling to clearly evaluate impacts is in the area of land use impacts of transportation investments, particularly transit investments. While we are sure there is a relationship, it is absolutely clear that we are far from a consensus regarding the nature and magnitude of these impacts. As recently as the November/December 1996 issue of TR news, some of the foremost experts on the subject postulated very different assessments of land use impacts from transportation investments.

We particularly cite land use impacts as virtues of rail transit investments, and indeed there is evidence of impact. Yet, Atlanta, Georgia, where a tremendous sum of dollars has been invested in rail, has been labeled in the local media as "probably the fastest growing metropolitan area (in physical size) in the history of the world."

Recently, Paul Weyrich of the Free Congress Foundation wrote an article for APTA noting the ability of transit to reestablish a sense of community in our urban areas. I can't wait until planners try to evaluate projects based on the extent of "sense of community" that they create.

Our expanding goal set, while well intended, may be resulting in planners being incapable of providing accurate, meaningful or reliable data for informed decisions?

If we are going to have an expanded goal set, we need established, credible means of measuring goal attainment. We need to keep working on our methodologies for forecasting, measuring, and valuing impacts. Over the past few years the terms "junk science" and "junk research" have been used in the media to refer to advocacy driven findings that do not meet the standards of valid scientific or statistical methodologies. We need to be very careful that our transportation analysis does not become "junk impact assessment."

Second, this expanded goal set increases the number of players in the planning decision- making process. There is a risk that we have made the process so complex that no one can understand the decision-making sequence for major decisions and we have virtually assured a long, expensive, cumbersome decision-making process. Some years ago I coauthored a paper suggesting that planners do a decision map to outline the sequence of decision-making steps and actors. Indeed as we expand our range of involved parties it will be critical that we fully understand the respective roles and responsibilities in the planning/decision-making process.

I cannot count the number of times I have heard the public say, "Its time to stop planning and time to start building." Yet, with the decision processes we are putting in place, we may never get to implementation. Perhaps it is fortunate that there are resource limitations, otherwise the pace of planning and decision-making might come under much greater scrutiny.

While I would not want to disenfranchise anyone, and a little time and money are well spent for good decisions — we risk making transportation investments that try to do everything but do nothing well.

The **third** factor that makes me nervous about the broad range of goals is that we are not being true to the problem definition by having a solutions set composed of strictly transportation investments. Let me explain.

If I am trying to move people, save energy and influence land use, I may favor a rail system investment over roadway construction to accomplish these goals. However, I am only looking at transportation investment options to accomplish a range of goals that extends well beyond moving people. Perhaps I should include, in my choice set, a range of investment and policy options that address these goals from different perspectives. For example, in my choice set, I most likely do not evaluate an investment in an HOV lane coupled with a land use policy change and economic development incentive package. Perhaps a lower cost transit investment coupled with a tax free development zone system would result in more optimal overall benefits. Yet, this is not a choice, since the funding and decision-making forum are transportation focused.

In some instances, transportation funding and transportation decision-making forums become the focal point for decisions that go well beyond providing transportation. The further beyond transportation benefits we go, the more it behooves us to look at packages of alternative investments and policies that have elements in them that have nothing to do with transportation.

The **fourth** and final aspect of the broad goal set concerns how we do planning and make decisions for these broadly defined goals.

Over the years we have often sought single purpose entities to plan and certainly to implement transportation projects. The theory was that we would get a dedicated agency with a clear mandate and mission to provide transportation facilities and services. This single purpose agency was theoretically not bogged down in general purpose government issues and transportation decisions would not be held hostage to politics or competing priorities. The dedicated agency provides a forum and a focus for action.

However, as transportation is increasingly defined as part of a larger whole, it may be time to revisit this issue. Perhaps we could end up with better integration of transportation investments with other aspects of our infrastructure investments, policies, and programs if we put transportation decision-making back into general purpose governments. Specifically, perhaps transit agencies could be more effective if they were closer to the land use planning responsibilities. Portland has certainly evidenced the value of coordinated planning of land use, roadways and transit investments. If we tried placing transportation within a general purpose government, and did not make progress on transportation issues, then perhaps there is not the mandate that we in the profession imagine for more transportation investment.

Similarly, if our goals are jobs, energy savings, land use impacts, and transportation, perhaps multiple funding sources associated with each goal should be sought for implementing projects. Transportation funds might pay for the majority of costs, however, to the extent that the most efficient transportation investment was rejected in order to accomplish other goals, perhaps other sources of funds should be sought to pay for these benefits. Maybe we would have adequate transportation resources if other sources of funds were sought to pay for benefits beyond those strictly attributable to the transportation improvement.

I warned you that some of these ideas were meant to stir up your thinking and might not be consistent with traditional perspectives.

Prescribing the Future?

The second major issue I wanted to raise deals with the issue of prescribing the future rather than predicting the future. For years the transportation planning profession has focused a great deal of time on forecasting what the future might be like and how it can best be served by transportation investments. We may be quickly moving from an era where we focused on predicting the future to one where we appear to be more interested in prescribing the future. Such a change may require a fundamental rethinking of how we go about doing planning.

There are several reasons for this change. First, in many of our urban areas, the built environment is more substantial than historically was the case, and the increment of change in a new plan is necessarily more modest as a share of the total infrastructure. Thus, there is less uncertainty to doing predictions.

Second, we are significantly behind in our infrastructure investments. In many cases we do not need to forecast demand, we can count it. We are not building roadway investments for tomorrow's needs but rather for yesterday's or today's needs. Why predict future needs when we cannot afford to build them?

Third, we appear to be more willing to consider pro-active policies and investments. Some might consider this social engineering where we are willing to be more aggressive in making sure that the market responds in the way we want. Others would simply call this leveling the playing field or moving toward full social cost accounting for transportation policy. In any case, we appear to be willing to utilize resources in ways that shape the future rather than simply responding to it. The broad-based interest in increasing alternatives to the single occupant vehicle often suggests prescribing an investment plan designed to shape future choices by providing transportation capacity that does not necessarily match today's market statements of need.

If this is, in fact, the path we are taking, it suggests a huge range of impacts on how we go about doing our transportation planning.

Many of the transit studies we are doing now do not focus on whether we need rail now or in the near future, but rather on what level of development, parking capacity constraints or other factors will be required to make the transit investment effective in the future. We seem far more willing to lead rather than follow the public, yet this new direction has not necessarily been explicitly endorsed or acknowledged by the professionals, the public or the decision makers. We may be well served by being more explicit of our intentions and the risks and uncertainties in this new direction. This role as a prescriber of the future may require the planner to have a different set of skills and experiences than in the past.

This role as a prescriber of the future may require us to focus our attention on a smaller segment of the market. It is highly unlikely that we can make-over our urban environment at the regional scale, but rather may be appropriate at the corridor or neighborhood level. If, for example, we want to alter land use via investment in a rail system, we may be best served by focusing our investment dollars in a small enough area to make a real impact. Often the combination of our mode-specific agency agendas combined with our desire or mandate to be equitable in our allocation of transportation investments, results in our being forced into one- size-fits-all solutions to urban mobility. This strategy may not work for diverse regions with varying needs and interests.

The transportation needs, and the ability or desire of various areas to support a given investment or set of policies may vary dramatically across urban areas, yet, we often prescribe a single system solution to mobility problems. I am often intrigued how we determine that a rail investment is a fitting investment to support and reinvigorate an urban area, but then we proceed to extend that system into the far flung suburbs in an effort to chase the market and be equitable in our allocation of resources. Perhaps no rail lines should extend more than ten miles from the city center and those persons living farther away simply have to suffer the congestion and other consequences of not being readily served by high performance urban transit services.

Where Have All the Analysts Gone?

The final major issue I would like to raise is the role of the planner as an advocate versus an analyst. Over the past few decades we appear to have moved ever closer to the situation where most transportation planners are in fact advocates for a particular mode or solution to our mobility problems. This appears to have arisen from a combination of factors including our tendency to have mode specific agencies, the tight resource situation forcing some competitive fighting among agencies for dollars, and perhaps the inherent need to specialize in a given mode in our increasingly complex planning environment. Yet, this tendency may be resulting in us losing our objectivity when it comes to evaluating investments and policies. We seem to be in a culture that highly values positive team play and is quick to characterize any pragmatic assessments as "doubting Thomases" who don't have the vision, are too negative, or aren't team players.

I do want to be a little bit alarmist on this point.

In the sixties we heard comments like, "The military industrial complex never met a weapons system that it did not like," and, "The Army Corp of Engineers never found a river that did not need a damn." I am afraid that the transportation industry is having trouble finding an intelligent transportation system project that isn't critical to our national interests, an urban area corridor that does not need a light rail system, a bus system that doesn't need an automatic vehicle locator system, or a highway that doesn't need at least two extra lanes. While we have projects that are not affordable, we have very few that are judged not worth implementing.

A number of the things we do perpetuate this tendency. There is the single purpose agency. In Florida, the Tri-county Commuter Rail authority did a strategic plan — guess what mode they recommended needed to be expanded?

Discretionary funding is another culprit. Targeted discretionary funding is far and away the best way to unlevel a playing field. If the choice is — build a given type of project or don't get the money — not surprisingly the answer is a recommendation to build a project that matches the eligibility criteria for the funding source.

Even at the federal level, we (or they) have washed our hands of passing judgement on the relative merits of alternatives. That is now a local decision and the "Feds" are your partner in implementation. Nobody wants to be the person who says no or asks the tough questions. Why alienate someone by telling them their project is low priority — simply let the lack of resources kill the project later or see it get funded on someone else's watch. In the mean time, keep spending money on the planning and don't risk losing good will with a constituent.

In other ways we are hiding under the covers when it comes to objective evaluation of projects. One of the virtues of the ever expanding goal set is that we can cite the desire to attain some unmeasurable new goal as the basis for favoring a given alternative. If it can't be measured, it can't be argued. We may have created a situation where no one is watching the purse strings. Advocacy has become an extraordinarily influential aspect of transportation planning and investment decision-making. Where have all the analysts gone?

A few years ago I was talking to a friend who was involved in an alternatives analysis in a Midwestern city. He casually said that he sure hoped that the project would move into the engineering stage. I commented, "Oh, is it a good project?" He responded, "No, its not that, but my kids are in high school and I don't want to move again for a few years and there are no other transit jobs in town." About ten years ago I had a senior consultant from a well known firm pat me on the shoulder and explain that the only way we ever get anything implemented is if we exaggerate a little in advocating our favored projects.

Just this past fall I was reviewing a paper submitted to the Transportation Research Board. The authors stated, "The public was not supportive of the project as we neared the end of the planning stage, so we redesigned the citizen participation process to build support for the project." Is that what we really want to be doing?

I suspect that most planners can relate to situations where you or someone you know has rung their hands in frustration with a "stupid" decision, yet the defining issues or the uncertainty inherent in the decision were not communicated to the decision makers.

Does the planning environment that we have helped create facilitate an objective, information-based decision process? I fear not!

A few years ago the country watched in horror and embarrassment as the chief executive officers of six tobacco giants publicly lied about their prior knowledge regarding the risks of smoking. While I am not accusing transportation professionals of lying, I am suggesting that we are creating an environment where the motivations may bring out the worst in people. It wasn't shocking to me that these individuals lied, but rather that the public was naive to the motivational pressures that created that temptation. Our institutional and funding structures create tremendous pressures for transportation planners to be advocates and not analysts. I think we need some of each.

While we have argued for a multi-modal process, has our institutional structure and competition for resources kept us from developing a true multi-modal planning perspective?

Conclusions

Not surprisingly, one can draw several conclusion from this set of issues. In fact, I did, rewriting the conclusions several times. Several key points merit reiteration.

Clearly planners' plates are full. In some respects, things have never been better. We have the best data sets and planning tools ever. We have the benefit of a growing body of relatively well documented experience. We have a diverse, well educated, and professional human resource base to call on. We have increasingly sophisticated methodologies to assess the consequences of our planning. But we have the most complex technical and institutional environment for decision-making. We have limited resources and we have an unparalleled degree of cynicism in the public and the media.

I believe it was in 1992, when the political pundits coined the term "Its the economy stupid!" to characterize the critical issues in the minds of voters. At this time I think we in the transportation planning profession would benefit by having a screen-saver on each of our computer monitors that says "It's the traveler stupid!" in order to keep us focused on our fundamental mission. If we are to embrace an expanded vision of transportation and acknowledge the interrelationship of transportation to the overall quality of life and economic well being of our community — that's good — but we should make sure we have a mandate to do that, adequate resources, and the appropriate expertise to do it effectively and accurately.

If we continue to move toward a day when we no longer forecast the future, but rather prescribe it, we need to get that mandate more clearly endorsed by the public and decision-makers. We need to recognize that it will require a different set of skills and perhaps a very different relationship between the technical and political aspects of planning.

If planners desire or are required to play the role of advocates, then we may need to rethink the structure of planning and decision-making. Somewhere, someone should play the role of analyst. If we need to be advocates then let's say so so the public and decision-makers can evaluate information accordingly.

Yes, we do have challenges and opportunities in front of us. We have a long history of accomplishment in transportation planning and engineering that will not be easy to live up to. We have the resources and the capabilities, we need to muster the resolve to be enlightened yet focused, visionary yet pragmatic, leaders yet servants, and analysts yet advocates — advocates for good transportation.

Time-of-Day Stratification and Its Impact on Traffic Assignment and Vehicle Emission Estimates

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Abstract

The Clean Air Act Amendment (CAAA) of 1990 has greatly impacted the transportation planning process. One of the requirements of CAAA is to estimate vehicular emissions, a major source of air pollution. The forecasting of vehicular emissions is based on the projections from travel demand forecasting model. Consequently, any changes in the travel demand model would affect air pollution forecasting. In response to the CAAA, the Denver Regional Council of Governments (DRCOG), as a federally mandated Metropolitan Planning Organization, is revising its transportation modeling process, especially in the traffic assignment procedure which is closely related to the time -of-day (TOD) stratification.

The study used the Denver regional travel model as a study case to explore the influence of different TOD stratification techniques to the assignment results and vehicle emission estimates. Experiments were performed on three basic TOD stratification methods, a single period assignment, a three period assignment and a 24 hourly assignment. The HCM85 based volume-delay functions were used in the assignment processes and the resultant speeds were inputs to MOBILE5A, a mobile source emission factor model, to produce emission factors for each of the three test cases.

The study analyzed difference in traffic assignment performance between test cases, and examined their impacts on vehicle emission estimates. The study also discussed the spatial distribution changes of VMT, speed, and three major pollutants: HC, CO, and NOx, between highway facility types.

The study concluded that the three period assignment had the advantage over single period assignment of being able to differentiate the traffic situation between peak and off peak periods. However, the speeds in the three period assignments were produced under the worst traffic congestion conditions. The 24 hourly assignment procedure significantly improved the travel speed estimates, especially for the peak periods by further differentiating the O-D table into shorter periods. As a result, more reasonable vehicle emission estimates for the three major pollutants were produced. The study also verified that the emission estimates are very sensitive to the speed changes among the three different TOD stratification methods while VMT presents a secondary role.

To reduce computing time and operation complexity, an average TD factor method was developed and recommended to reduce number of periods required for the off peak assignment without hurting the accuracy of the results.

The Tampa Bay Regional Transportation Analysis Phase II - Bridging the Development of Local Long Range Transportation Plans and a Regional Strategy

Daniel Lamb, Florida Department of Transportation; and Wade L. White, Gannett Fleming, Inc.

Abstract

The Tampa Bay Regional Transportation Analysis (RTA) is a broad level process for the conduct of regional planning and coordination of local planning activities in the Tampa Bay area. The process functions as a collaborative effort among the Florida Department of Transportation District 7 (FDOT) and four local Metropolitan Planning Organizations (MPOs); The Hillsborough County MPO, the Pinellas County MPO, the Pasco County MPO and the Hernando County MPO. The process is directed by the Tampa Bay Area MPO Director's Coordination Team, with policy guidance from the Tampa Bay Area Chairmen's Coordinating Committee. Technical analyses and guidance are provided by the Technical Review Team (TRT).

Phase I, as the predecessor to this project, developed a single regional transportation planning model for the area. This model contained all the details of the previously developed MPO urban models with substantial enhancements to trip generation, trip distribution and highway network coding. Phase II supported the development and update for the MPO's Long Range Transportation Plans (LRTPs) in a coordinated and consistent fashion. Together, Phase I and II of the RTA have facilitated the LRTP development process by providing on-going forum of the discussion of regional issues, coordination of planning activities, resolution of conflicts, and the sharing of resources to accomplish common ends. Overall, the RTA enabled a unified modeling approach by providing the MPOs with a set of planning tools specifically tailored to the unique characteristics and needs of the Tampa Bay Area. The networks and databases which drive these models are regional in scope, yet detailed enough to allow individual MPOs to address local issues. This enabled each of the MPOs to develop individual LRTPs which were both responsive to local priorities and issues yet supportive of broader regional aims and coordination.

This report describes how the RTA has promoted the development of regional transportation strategies as well as the LRTP alternative development, network coding and evaluation processes. Key to this coordination has been the use of a single modeling and analysis process for the development and update of all local LRTPs.

As part of Phase II, 86 LRTP alternatives and scenarios were tested. To help decision-makers evaluate the impact of alternative transportation scenarios, the TRT developed a standard set of model output summaries for each county and for the region a whole. Air quality, transit patronage, auto occupancy, and various measure of congestions, accessibility, mobility and overall system usage were selected by the TRT to show how well each alternative serve the intent of public policy.

Lessons learned from this project will be applied in the next phases of the Tampa Bay Regional Transportation Analysis. Major enhancements will include an emphasis on goods movement as well as person movement, testing of alternative land use policies, automated scenario management, enhanced reporting, and an ARC/INFO interface. Each enhancement will expedite coding, summary and presentation of LRTP alternatives and their anticipated effects.

Highway Network Validation Using Enhanced Area Types and Facility Types to Integrate 1994 HCM Capacities, the FSUTMS HNET Procedural Enhancement Study

Robert Schiffer, Daniel J. Beaty, and Wiatt F. Bowers, Post Buckley, Schuh & Jernigan, Inc.

Abstract

The Florida Standard Urban Transportation Model Structure (FSUTMS) represents a formal set of modeling steps, procedures, software, file formats, and guidelines established by the Florida Department of Transportation (FDOT) for use in travel demand forecasting throughout the State. The purpose of the HNET Procedural Enhancement Study, funded by the FDOT/Central Systems Planning Office and sponsored by Florida's Model Task Force, is to implement two digit area type (AT) and facility type (FT) methodologies for highway network coding and model validation.

The concept of area types and facility types dates back to the 1979 version of the UTPS travel demand model forecasting package. The rationale was to eliminate (or at least minimize) individual link coding of network characteristics such as speed and capacities, opting for a lookup of area types and facility types. Use of area types and facility types greatly simplified the process of network coding, and enhanced the credibility of network-oriented model validation adjustments.

However, as time has passed since the early days of UTPS, new advances in computer technology, roadway design and the measurement of highway capacity have occurred. FDOT, in particular, has developed its own detailed Level of Service (LOS) manual, based on the 1994 Highway Capacity Manual (HCM), which recognizes the significance of signal density on highway capacity. In order to maximize consistency with FDOT LOS Manual capacities, and model a variety of new roadway concepts, the five standardized single- digit area types and nine facility types have been expanded.

In order to test alternative network methodologies, the coding of two digit area types and facility types was completed for three urbanized areas in Florida. Jacksonville, Pensacola, and Vero Beach were selected as test sites for large, medium and small urban areas, respectively. Initial coding methodologies were based largely on recent efforts in the Tampa Bay area. Newly prepared capacities based on the 1994 HCM and the 1995 LOS Manual, were used as a starting point for validation testing. Initial free flow speeds were based largely on earlier FDOT Model Research with some added assumptions for new AT/FT categories.

Alternative Structures for a Vehicle Availability Model for the Philadelphia Region

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Abstract

A new disaggregate vehicle availability model has been developed for DVRPC, the MPO for the Delaware Valley (Philadelphia) metropolitan area. The development of the model included an exploration of two alternative model structures and was based on a data set which includes a number of alternative variables measuring both travel accessibility by mode and the quality of the pedestrian environment. Each of the candidate models has five alternatives: zero, one, two three, and four or more household vehicles available. The alternative model structure include a standard multinomial logit (MNL) and a series of ordered response binary logit (ORL) models. The MNL model reflects the assumption that households choose, at a single point in time, which of the five vehicle availability levels they will have. The ORL models assume that households reach their final vehicle availability level in a sequential manner. First, they decide whether or not to have a vehicle or to have one or more vehicles. If they decide to have one or more vehicles, this process continues by deciding whether to have one vehicle or to have two or more vehicles. Subsequent steps of the same type occur until one of the original five alternatives has been selected.

The alternative model structures developed for DVRPC both include the following types of variables:

- Household characteristics such as annual income, household size, and number of workers;
- Characteristics of the zone of residence including population, household and employment densities;
- Subjective assessments of factors affecting the pedestrian environment, including sidewalk availability, ease of street crossings, building setbacks, and street connectivity; and
- Zonal highway and transit accessibility measures such as the number of jobs which can be reached within stated times by each mode.

It was possible to estimate acceptable models for both the MNL and ORL structures. The choice of the final recommended model structure was based on considerations of overall accuracy in replicating base year survey and Census data, on the geographic distribution of the errors of each model structure, and on the reasonableness of the alternative future-year forecasts. The paper will present the background of the modeling effort, discuss the bases of the two alternative model structures, summarize the estimation results, show the comparative validation done of each structure, and discuss the resulting selection of a final model for the Philadelphia region.

Comparison of Several Traffic Assignment Options

William W. Mann, Bahram Jamei, and Mazen Dawoud, Virginia Department of Transportation

Abstract

Five capacity restraint highway assignment options are compared in a 2020 highly congested environment to select the one best suited for future subarea studies in Northern Virginia. The highway network and trip table models used in this research were developed by the Metropolitan Washington Council of Governments for the Washington region, for which Northern Virginia is a part.

The assignment techniques tested were: equilibrium, four (4) iterations of capacity restraint, ten (10) iterations of capacity restraint, stochastic, and four iterations of capacity restraint with node-delay function

The software used was MINUTP and TP4in1. Several conclusion are made and the assignment technique providing the most desirable results is the fifth option tested four iterations of capacity restraint with the node-delay function.

Knowing how the algorithms behave comparatively in highly congested situations is helpful for other metropolitan planning organizations to decide if they need to reconsider using other assignment techniques than the ones they are currently using.

Transportation Data Quality: What It Means And How To Get It

Ken Cervenka, North Central Texas Council of Governments

Abstract

Attempts to significantly improve travel demand forecasting procedures should consider the availability and quality of data in four primary areas: transportation supply (e.g., roadway and transit networks), land use information (e.g., population and employment estimates and forecasts), observed travel (e.g., time-of-day motor vehicle counts, transit ridership, and travel times), and behavioral information (e.g., the activities and travel of individuals). This paper and presentation will address all four areas, but fill focus on the recent collection of travel survey data by the North Central Texas Council of Governments (NCTCOG), the Metropolitan Planning Organization (MPO) for the Dallas-Fort Worth region.

The author's findings are based on first-hand experiences with the management of four projects (external travel survey, workplace survey, household survey, and transit onboard survey) administered by four separate consulting teams, as well as interactions with Los Alamos National Laboratory on the conceptualization of a "next generation" travel model. Any agency considering a new survey should first contemplate the issues that will impact the quality of the collected data, such as survey objectives; degree of risk; and trade-offs between the cost, quality, and quantity of the data collected.

Look up the word "quality" in the dictionary and you will see definitions such as "degree of excellence" and "superiority in kind." A more pragmatic definition of "data quality" for the transportation planning community is "information that leads to better transportation decision-making." And how do you get this kind of data? The answer seems simple: 1) figure out (as best you can) what you really need; 2) design a program that fits within your constraints; and 3) implement the program. The degree of success for any data collection program centers on how well these three tasks can be accomplished.

For the discussion that follows, the perspective of a Metropolitan Planning Organization (MPO) responsible for travel demand forecasting is taken. An MPO is charged with the responsibility of developing and maintaining the region's transportation plan, which serves as the blueprint for the region's future transportation system. Ultimately, an MPO's objective is to improve the "quality of life." Following some background information, the topics covered include a description of four types of data, hypotheses on data collection, data collection objectives, and some closing thoughts.

Background

The North Central Texas Council of Governments (NCTCOG) is the MPO for the 5,000-square-mile, four-million-person Dallas-Fort Worth Metropolitan Area. An alternative title for this paper could have been "Lessons Learned From Dallas-Fort Worth Experiences," for the author's knowledge of data quality issues is based on involvement in three major activities:

1. *Travel Model Development.* Since the late 1970s, NCTCOG has been running a highway/transit travel demand forecasting model that resides on an IBM mainframe computer. It is primarily a customized version of the Urban Transportation Planning System (UTPS) package

developed by the U.S. Department of Transportation in the 1960s and 1970s. The last major round of model calibration/validation was conducted in the late 1980s and was based on the 1984 household, workplace, and transit on-board surveys; the 1980 U.S. Census Journey-to-Work data; and highway and transit passenger counts. NCTCOG has spent considerable research time, in recent years, identifying the functional requirements and data needs for a near-term and long-term travel demand forecasting system that will reside on in-house computers.

2. *Regional Travel Surveys.* In the 1994-1996 time period, NCTCOG organized a number of surveys that had three primary objectives:

   - To obtain data needed for re-calibration of the existing four-step model process for the Dallas-Fort Worth Metropolitan Area;
   - To provide the data needed for testing new demand model strategies; and
   - To develop broader, more management-oriented (and policy-sensitive) forecasting procedures.

   Five major survey efforts, with an overall price tag of 1.5 million dollars, have been completed:

   - The External Travel Survey (by Wilbur Smith Associates) consisted of roadside interviews of 28,000 drivers at 38 locations (outbound direction, as the vehicles left the Metropolitan Area) in March and April of 1994.
   - The Workplace Survey (by Barton-Aschman Associates, Inc.) consisted of 20,000 visitor interviews and 7,000 completed employee questionnaires for 278 workplaces from September to November of 1994.
   - The Transit Origin-Destination Survey (by NuStats International) consisted of 4,075 completed questionnaires obtained from riders of the Fort Worth Transportation Authority's fixed-route services in May of 1996.
   - The Household Activity Survey (by Applied Management and Planning Group) consisted of the completion of one-day diaries for all members of over 4,000 households from March to May of 1996.
   - The Stated Preference Survey (by Applied Management and Planning Group, with Mark Bradley Research and Consulting as subcontractor) consisted of "trade-off choice" questionnaires mailed back by more than 500 individuals who had previously participated in the Household Activity Survey. The mail-out/mail-back survey was conducted in the summer of 1996.

3. *TRANSIMS Case Study*. TRANSIMS (TRansportation ANalysis and SIMulation System) is a "next generation" travel simulation and forecasting system being developed by Los Alamos National Laboratory (LANL) as part of the multitrack, multiyear National Travel Model Improvement Program. It is referred to as a "bottom-up" computational approach because the simulated interactions of individual behaviors are used to observe aggregate dynamic (i.e., emergent) behaviors. NCTCOG has been working with LANL since 1995 on a case study application of the first interim operational capability of TRANSIMS: Traffic Microsimula-

tion. The experience has given NCTCOG staff new insights about the large-scale needs for different types (and accuracies) of data.

Four Types of Data

The theme of this paper is that data quality refers to "information that leads to better transportation decision-making." As viewed by a travel modeler, there are at least four primary types of data that will impact a travel model, and, ultimately, the value of the transportation decisions that are based on the travel model results:

1. *Demographics (Land Use)*. These are the estimates and forecasts of all variables needed for calculating person trip (or activity) production and attraction rates and input values for mode choice calculations. Typical zone-based examples include population, households, average household income (or income distribution), auto ownership, employment, and area type.

2. *Transportation Supply*. Examples include the specification of all attributes of roadway links/intersections and transit routes/stops that are needed for a travel model run.

3. *Observed Travel (Aggregate Transportation Demand)*. Examples include time-of-day counts (for all relevant modes of transportation) and observed highway/transit travel times for specific time periods. The information is not used as input to a travel model, but rather as a means of calibrating (and ultimately validating/verifying) a travel model formulation. [Note: a mistake made by some modelers is to assume that the data used for model calibration can also be used for model validation].

4. *Behavioral Information (Disaggregate or Individual Transportation Demand)*. Examples include information about the actual activities and travel of individuals (revealed preference), as well as their predicted activities and travel under non-observable conditions (stated preference/stated response). For detailed information about the many kinds of surveys for obtaining behavioral information, refer to the June 1996 U.S. Department of Transportation and U.S. Department of Energy report, Travel Survey Manual.

Hypotheses on Data Collection

Here are six hypotheses (or assumptions) to be considered, prior to development of a detailed data collection program design:

1. There are uses for data that go beyond the direct needs of travel demand models. Demographic and land use data, for example, is used for a variety of planning purposes. Observed travel data can be used for preparing detailed summaries of transportation system performance and behavioral data can be used for policy analyses. For example, even if information about "work at home" patterns is not expected to be incorporated in a travel model, the information may be useful for preparation of a Travel Demand Management (TDM) program.

2. The ultimate value of any travel demand model is tempered by the availability and accuracy of existing/predicted data. A term coined in the 1960s, with the advent of increased computer usage, is GIGO: Garbage In/Garbage Out. Concerns with GIGO are just as relevant today as they were 35 years ago. Data is needed not only to calibrate and validate the equations and parameters contained in new travel model formulations, but must be forecastable for use as input in future model runs.

3. The ultimate value of any travel demand model is also tempered by how (or whether) the available data will actually be used. For example, a program to gather detailed signal timing/phasing data will not improve a travel model if there is no mechanism for incorporating this level of intersection detail. For another example, it is common practice to "throw out" travel time runs that occurred during unexpected events (e.g., a freeway accident), but yet this may give us good information about the frequency of non-recurring congestion and the reliability of a roadway segment.

4. It is not clear whether we should get the data to fit the models we want, or develop the models to fit the data we can get. Should our data collection program be designed to meet the requirements of a specific travel demand model construction, or should we instead be using the data to help us develop a new model structure?

5. The best approach for one agency will NOT be appropriate for all agencies. Perhaps one way to deal with Assumption #4 is to realize that some agencies are willing to accept the risks associated with "pioneering research," whereas other agencies are content to follow established practice. Agencies (as well as their employees) simply have different opinions about operating outside of their "comfort zone."

6. No data collection program will ever be perfect. The "Holy Grail" of a perfect data collection program is simply not attainable, at any cost. Some compromises and risks will be necessary, for we cannot conduct new surveys every time we think of a new data item that might be of value to the next round of model development.

Data Collection Objectives

If the organization paying for and using the data (the client) is different from the organization collecting the data (the contractor), it is likely that the program objectives for these two organizations will be different. The ultimate value (i.e., quality) of the collected data will depend on how each party deals with their separate objectives. For example, consider the data collection objectives from the perspective of a client that will be performing travel model calibration/validation:

1. There is a purpose for collecting data that goes beyond simply collecting data. While the delivery of the data may be the contractor's final product, the client's real work is just beginning. If the data is not expected to improve the client's transportation decision-making process in some definable way, then there is probably no valid reason for collecting the data in the first place.

2. Time and/or cost constraints are most likely prevalent in all decisions. The client would, of course, like to find the contractor that can deliver the highest quality (and quantity) of data at the lowest possible cost, in the shortest possible time, and with no risk to the client. In reality, some compromises will need to be made, and the client's early task is to choose the contractor that (in the client's opinion) will most likely deliver the "best" overall product.

3. The contractor must ultimately deliver what the client considers the "best possible" product. From the client's perspective, the contractor should deliver all work that was promised, as well as "cover" any additional requests the client makes during the contract period. In reality, the client must work closely with the contractor to make various trade-off decisions and compromises, even after the final contract has been signed.

The contractor, on the other hand, may be working under a different set of objectives that center on the fact that a particular data collection effort is just one of many commercial transactions for the firm:

1. The contractor is running a business. To stay in business, the contractor must, over the long run, “make money” on many (although not necessarily all) projects.

2. The contractor is in competition with others. A particular data collection effort is “won” by offering a proposal that is most attractive to the client (in some way) then the competitors’ proposals. It is therefore not always possible for the contractor to propose what he/she would really like to do (i.e., deliver the highest-quality product), but rather what the future client thinks should be done.

3. The client is expected to be “reasonable.” Problems will most likely be encountered during any large data collection program, which means that a good client/contractor relationship must be established and all roles clearly defined.

4. The contractor wants to please the client and do meaningful work. It is generally “good for business,” over the long run, for the contractor to not only deliver a product that meets all contractual obligations, but to deliver what the client will consider the “best possible” product-even if there is an extra expense that cannot be charged to the client.

Some Closing Thoughts

As noted at the beginning of this paper, transportation data quality can refer to “information that leads to better transportation decision-making.” A data collection program should be designed so that it gets the data that’s really needed, within the known time and cost constraints. Here are a few closing thoughts for an agency planning a new data collection program:

1. The ultimate objectives for use of the data should be defined, as much as possible, before any data is collected. Consider the use of a consultant “coach” or expert panel to help with the identification of needs.

2. Decisions must be made between potentially conflicting objectives: how much effort should be expended to get data to be used to update an agency’s existing four-step model, and how much should be expended in the pursuit of an alternative approach? Also, how much effort should be expended for data that is needed for purposes other than travel modeling?

3. Consider a risk assessment: can data collection methodologies implemented in other regions be used with only minor revisions, or is a major new survey design effort (with extensive pretests) warranted?

4. Are data summaries already prepared for other regions of value to your agency? If so, it may be possible to reduce (or redirect) your own data collection program.

5. If a contractor is hired, be sure that everyone agrees on the roles and responsibilities for data collection design and administration. Even a binding “iron-clad” client/contractor agreement requires trust and respect among the parties, especially if new procedures are being tested. Also, be sure there is agreement on how “acceptable quality” for the final survey data is defined.

6. Rather than seek the "Holy Grail" of all data collection efforts, it is easier to simply accept (and plan for) the fact that no program is going to perfect.

Activity-Based vs. Location-Based Household Travel Survey - A Comparison of Two Recent Pretests Conducted in New York Metropolitan Area

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Abstract

This paper presents the experience leaned from two pretests of a household travel survey conducted in New York metropolitan area. As part of its Transportation Models/Data Initiative project, New York Metropolitan Transportation Council (NYMTC) is planning to conduct a regionwide household travel survey with a sample size of 12,000 households. To ensue the survey's success in the 31-county study area with complex travel and demographic characteristics, two pretests were conducted in the past year. This paper discusses the similarities and differences of these two survey pretests. The survey instruments used in these two survey pretests were different. Both pretests used Computer Aided Telephone Interview (CATI) programs to record information, however, the second pretest used worksheets to record travel information instead of CATI. With a sample size of 300 households, the first pretest used "activity-based" concept to design the travel diary and to retrieve and record travel information. With a sample size of 250 households, the second pretest used "location-based" concept which tried to trace the movements of an individual among different locations and the purposes of being at those locations. The organization of the paper is as follows.

Section 1 states the background of the household travel survey with emphasis on its integration with the need of land use, transportation and air quality models. Section 2 presents the overall design of the household travel survey and the major differences between the two pretests. Sections 3 and 4 illustrate and discus results of the first and second pretests, including sample size, recruitment rate, retrieval rate, interview length, and problems encountered. Section 5 compares the results of the two pretests and discusses their implications. Section 6 summarizes the findings and provides suggestions on future design and implementation of household travel surveys.

Detailed Forecasts for A Freeway Operation Study - Integrating Video Survey Data with a Regional Model

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Abstract

The I-395/14th Street Bridge Corridor is a highly congested multimodal corridor that links the District of Columbia and its Virginia suburbs. The Virginia Department of Transportation, in cooperation with other local and federal agencies, engaged BMI to perform a study to identify near and long term operational and design improvements for the Freeway and Bridges that serve the corridor. Detailed travel forecasts for 2000 and 2020 were developed for the corridor using the regional forecasts available from the MPO and to adjust origin-destination data collected in 1996.

More than 40 heavily used entrances and exits provide access to the three plus miles of I-395 between Route 27 in Virginia and L'Enfant Plaza in the District of Columbia. Some segments of the facility currently serve more than six thousand passenger vehicles per hour on each lane over the three-hour peak period. Traffic forecasts were needed for every entrance and exit and the many weaving movements in the corridor. These forecasts were input to CORSIM and CORFLO models that simulated future operating conditions of the Freeway and a related arterial corridor. Traditional traffic forecasting approaches were not well suited for developing the detailed traffic forecasts required.

Existing origins and destinations for all vehicles entering and exiting I-395 were obtained using an innovative video data collection technique. More than 200,000 license plate numbers were obtained using nearly 105 video camera locations. These license numbers uniquely identified all vehicles that entered and exited the study area during the AM and PM peak periods. Nearly 90 percent of these license plates were successfully matched and origin destination tables were developed for each half hour period.

This information was used to develop detailed 1996 peak period traffic assignments for each of nearly 100 entrances, exits, mainline links and express links in the study area. Results from the MPO's regional travel forecasting model were integrated with these assignments to derive future traffic forecasts for the facility. Select link volumes for 1996, 2000, and 2020 were estimated for each origin-destination pair using the MINUTP software package. These were then used to create growth factors that reflected target year traffic growth based on the future regional land use and transportation network. Resulting assignments were plotted to the corridor network using GIS software.

This paper describes the data collection and the traffic forecasting processes. Selected results are also presented.

Case Studies in the Application of Adjusted Census Data for Planning Projects

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Abstract

This paper details the reasons for differences between locally collected data and 1990 Census data as determined from a detailed analysis of model development efforts in two planning studies. Agencies around the country are beginning to use Census data that has been adjusted based on newly released Federal Highway Administration publication. A number of issues persist on why it is so difficult to match locally collected data and Census data.

A recently completed publication, *Transportation Planner's Handbook on Conversion Factors for Use of Census Data* has been published to assist planners in using the 1990 Census to develop and calibrate local travel demand models. Collecting new data to complete the development of a local model is not always an option. The 1990 Census provides another source of information to assist in traffic model estimation. Potential users of the Census need to be aware that there would appear to be a variance between results obtained from the Census journey-to-work files and locally developed home interview surveys, even after the use of the Census adjustment factors.

Recently completed projects in Hampton Roads, Virginia and Atlanta, Georgia involved detailed traffic model development and calibration, in conjunction with factor adjusted Census data. Because of the intimate understanding of the data for the study area, and the development of the model sets from the beginning, differences between the locally collected data and Census were explainable.

This paper details possible problems that can arise when comparing the data as they relate to geography, data definition and accuracy of the data collection process.

The 1990 Census Transportation Planning Package (CTPP) is the latest version of a program established for the 1970 Census and continued for the 1980 Census (Urban Transportation Planning Package) in the same general format. The 1990 CTPP is produced by the Bureau of the Census and funded by the various state departments of transportation. Planning and administrative costs were funded by the Federal Highway Administration and the Federal Transit Administration. The Federal Highway Administration also provides project coordination and technical support on the use and application of the Census. Census data as presented in the CTPP cannot be used directly for comparison to traffic forecasting models. Adjustment factors have been developed by the authors so that this data can be directly compared to traffic models and is detailed in the publication *Transportation Planner's Handbook on Conversion Factors for the Use of Census Data* (DTFH61-91-C-00079). This paper details the application of those factors to CTPP and then comparing those results to a traffic model developed in Atlanta, GA. Databases used for this analysis included:

CTPP

The Census Transportation Planning Package (CTPP) is a collection of Census data summary tables developed to meet the needs of transportation planners. The CTPP is primarily based on responses to the long-form Census questionnaire which is completed by one in six households. The long form includes 34 population questions for each person in the household and 19 housing questions. Due to the scale and complexity of the data, the CTPP is divided into two elements:

statewide and urban. The data contained in each element are comparable, and generally differ only in geographic scale. The statewide package was developed for each state and the District of Columbia. The urban package was developed for each CTPP "region" as defined by the region's Metropolitan Planning Organization (MPO).

PUMS Data

Another Census resource which is invaluable to transportation planners is the Public Use Microsurvey (PUMS) data. These files consist of random samples of individual disaggregate household records. Samples are provided at the 1 percent and 5 percent levels, the latter being of greatest interest for transportation planners. In order to ensure privacy of the individual data records the identification of geographic area is limited in the latter data set to areas not smaller than 100,000 population, referred to as Public Use Microsurvey Areas (PUMAs). These areas normally consist of counties or aggregations of counties. Where counties are large enough, PUMAs consist of subdivisions of counties. These data items provide the planner with the capability of aggregating household records in any form that is convenient for analysis. This is particularly useful in the generation of cross-classification trip generation models where information by individual travel zone is not important.

NPTS Dataset

The Nationwide Personal Transportation Survey (NPTS) was used to derive Census conversion factors. The sample size was large enough to permit stratification of some factors by metropolitan area size and normal travel mode. Normal mode is defined as the mode which the survey respondent indicated was their customary mode of travel to work. More important is the fact that the NPTS mode of travel was asked both in terms of an individual's normal mode-to-work during the past week, and in terms of a more conventional travel diary for all household members on a random day of the week. Thus the NPTS files contain all of the data necessary to generate conversion factors directly. Further, the definition of worker in the NPTS includes anyone who was working at all during the past week. This is consistent with the worker definition used by the Census.

TIGER Files

Procedures are currently available to apply Census Topologically Integrated Geographic Encoding & Referencing (TIGER) files to help determine the traffic analysis zone (TAZ) structure for a travel demand model. All major geographic information system (GIS) packages on the market currently have import functions for TIGER files. If traffic analysis zone boundaries are properly related to Census tract boundaries, then both model run results and Census data can be imported to the GIS for analysis.

Atlanta, Georgia Case Study

This paper provides a direct comparison of the application of Census data as adjusted using the factors developed in the Census factors study, to the actual four step model process as developed and calibrated in the greater Atlanta area for the Georgia Department of Transportation. Atlanta was chosen for study for several reasons. First, it is typical of a large growing metropolitan area with a full range of transit modes. Second, the models developed for Atlanta were based on a full range of carefully developed surveys undertaken in 1990 to be contemporary with the Census. Third, the analysts doing the comparison were intimately involved with the development of the models for Atlanta limiting the possibility that there might be inconsistencies in definitions that could bias the comparison; e.g., area coverage or trip type definitions. The comparison follows the conventional four-step modeling process and applies the Census data as it might be used to develop model components in the absence of locally collected survey data.

Trip Generation

The trip production models used by Atlanta are typical of what is considered to be good practice today. The model as currently applied is a cross-classification model that uses four categories of household size and four categories of auto ownership. The model was developed from relationships derived from a 1990 home interview survey conducted in the Atlanta metropolitan area.

A similar model was derived for comparison purposes from the 1990 Census Public Use Microsurvey (PUMS) files, for the Atlanta region, using identical definitions of household size and autos per household. A trip "production" is normally defined as a trip which begins or ends at home by a member of the household. Consequently, the Census is an excellent source of this data. The resulting Census derived model is compared with the model derived from local surveys in Table 1. The PUMS data sets are random samples of disaggregate Census data and as such are extremely useful products that complement the CTPP. These data sets provide ultimate flexibility in generating any possible cross section of data collected by the Census. Since PUMS data sets are derived from the same set of Census questions as the journey-to-work tabulations; this data must be adjusted using the same adjustment factors recommended for the journey-to-work files. Trip attraction models are normally derived as a statistical function of employment. The Census, unfortunately, can be of little help in this area as employment by place of work is not reported by the Census.

For most cells in the matrix the comparison is excellent with comparatively little variation between the two models. For zero auto households and for the two smallest household sizes the differences are more substantial. Viewing the progression of trip generation rates by auto ownership and household size in each row and column, there would appear to be irregularities in the progressions of both models, which might suggest the utility of using some composite of both models in a further refinement. Some cells also contain small sample sizes contributing to the differences.

Aggregate comparisons of the numbers of trips generated by the two models, illustrated in the row and column totals of Table 2, show an excellent match with an overall difference across the metropolitan area of only about four percent. Differences by county are almost as good with few differences in county to county movements exceeding five percent. Census derived estimates for the inner most counties, Fulton and Dekalb tend to be lower than the survey derived estimates. Conversely, the more rural counties tended to be somewhat overestimated. This difference between the inner and the more rural counties is predictable. A separate home interview survey conducted for the rural counties in 1993 showed lower overall trip generation per household than the survey of the inner counties in the region conducted in 1990. These same conclusions are supported by NPTS data.

The Census PUMS data is a powerful, inexpensive tool for metropolitan transportation planners that should not be ignored in the development of such trip generation models. Even if locally based survey data is available, comparisons with this readily available resource will provide an excellent quality control on the model to be developed.

Table 1: Atlanta HBW person trip generation by socio-economic classification

Survey					
Persons per household	Autos per Household				
	0	1	2	3	4+
1	0.16	0.82	1.02	0.82	0.86
2	0.27	0.99	1.77	1.86	1.94
3	0.37	1.71	2.29	2.70	3.06
4+	1.56	1.90	2.18	2.93	3.43

Census PUMS Data					
Persons per household	Autos per Household				
	0	1	2	3	4+
1	0.43	1.02	1.06	1.01	0.91
2	0.95	1.39	2.01	1.99	1.98
3	1.12	1.67	2.28	2.79	2.87
4+	1.04	1.88	2.30	2.86	3.42

Survey/Census Difference					
Persons per household	Autos per Household				
	0	1	2	3	4+
1	-0.27	-0.20	-0.04	-0.19	-0.05
2	-0.68	-0.40	-0.24	-0.13	-0.04
3	-0.75	0.04	0.01	-0.09	0.19
4+	0.52	0.02	-0.12	0.07	0.01

Percent Difference					
Persons per household	Autos per Household				
	0	1	2	3	4+
1	-170%	-25%	-4%	-24%	-6%
2	-251%	-40%	-14%	-7%	-2%
3	-203%	2%	0%	-3%	6%
4+	33%	1%	-5%	3%	0%

Table 2: Regional Distribution
Atlanta Home-Based-Work Trip Productions - By All Modes

Total Person Trip Productions Estimated from Census Data

External		14.2	47.8	29.8	5.2	5.9	79.6	28.5	4.8	7.8	223.4
Clayton	2.7	58.1	3.3	11.8	0.3	2.9	46.3	1.9	2.9	0.5	130.6
Cobb	13.4	8.5	167.5	24.0	3.7	0.2	111.0	8.6	0.1	0.4	337.5
DeKalb	7.3	10.6	13.3	178.9	0.4	0.3	151.2	29.2	0.6	2.9	394.7
Douglas	2.7	1.6	8.3	2.6	15.5	0.1	18.6	0.7	0.1	0.0	50.1
Fayette	2.3	11.4	0.9	1.3	0.1	13.2	12.5	0.3	0.5	0.0	42.4
Fulton	8.3	19.1	26.1	55.6	0.8	1.2	284.7	17.3	0.4	0.6	414.2
Gwinnet	9.1	3.6	9.0	71.7	0.2	0.1	51.8	124.5	0.2	1.8	272.0
Henry	1.7	11.2	0.7	5.0	0.0	0.3	9.2	0.7	11.1	0.5	40.4
Rockdale	3.2	1.4	0.6	10.1	0.1	0.0	6.0	1.9	0.4	14.3	38.1
Total	50.7	139.7	277.5	390.8	26.3	24.1	770.7	213.6	21.2	28.9	1,943.6

Total Person Trip Productions Estimated From the Local Model

External		13.9	50.0	29.9	5.2	5.7	79.6	28.5	4.4	8.0	225.1
Clayton	2.7	59.5	3.3	12.4	0.3	2.9	49.7	1.9	2.9	0.5	136.2
Cobb	13.5	8.7	170.4	25.0	3.8	0.2	114.2	8.8	0.1	0.4	345.1
DeKalb	7.0	11.9	13.3	187.1	0.4	0.3	169.0	29.5	0.6	3.0	422.0
Douglas	2.7	1.8	8.4	2.7	15.8	0.1	19.2	0.7	0.1	0.0	51.7
Fayette	2.3	11.7	0.9	1.3	0.1	13.4	12.8	0.3	0.5	0.0	43.4
Fulton	8.1	21.7	26.5	64.8	0.8	1.1	308.8	17.4	0.4	0.6	450.3
Gwinnet	9.1	3.9	9.2	73.7	0.2	0.1	54.9	126.7	0.2	1.8	279.9
Henry	1.7	11.4	0.8	5.1	0.0	0.3	9.4	0.7	11.3	0.5	41.2
Rockdale	3.2	1.5	0.7	10.4	0.1	0.0	6.3	1.9	0.4	14.6	39.0
Total	50.3	145.9	283.6	412.3	26.7	24.2	823.8	216.6	21.0	29.5	2,033.8

Census Based Estimate - Local Model Based Estimate

External		0.3	-2.2	-0.1	0.0	0.2	0.0	0.0	0.4	-0.2	-1.7
Clayton	0.0	-1.3	0.0	-0.6		0.0	-3.4	0.0	-0.1	0.0	-5.5
Cobb	-0.1	-0.2	-2.9	-1.0	-0.1	0.0	-3.2	-0.2		0.0	-7.6
DeKalb	0.3	-1.2	-0.1	-8.2	0.0	0.0	-17.8	-0.3	0.0	-0.1	-27.3
Douglas	0.0	-0.2	-0.2	-0.1	-0.3		-0.6	0.0			-1.5
Fayette	-0.1	-0.3	0.0	0.0		-0.2	-0.3		0.0		-0.9
Fulton	0.2	-2.6	-0.4	-9.2	0.1	0.0	-24.1	-0.1	0.0	0.0	-36.1
Gwinnet	0.0	-0.3	-0.2	-2.0		0.0	-3.1	-2.2		0.0	-7.9
Henry	0.0	-0.3	0.0	-0.1		0.0	-0.2	0.0	-0.2	0.0	-0.8
Rockdale	-0.1	0.0	0.0	-0.2		0.0	-0.3	-0.1		-0.3	-0.9
Total	0.3	-6.2	-6.0	-21.5	-0.4	-0.1	-53.0	-2.9	0.1	-0.6	-90.2

Difference in Estimates / Local Model Based Estimate

External		2%	-4%	0%	-1%	3%			9%	-2%	-1%
Clayton	0%	-2%	0%	-5%	-2%	-2%	-7%	-2%	-3%	-7%	-4%
Cobb	-1%	-2%	-2%	-4%	-2%	5%	-3%	-3%	-3%	-2%	-2%
DeKalb	4%	-11%	0%	-4%	7%	2%	-11%	-1%	-1%	-2%	-6%
Douglas	-1%	-13%	-2%	-4%	-2%	-1%	-3%	-3%	-1%	-4%	-3%
Fayette	-2%	-2%	-4%	-3%	-2%	-2%	-2%	-2%	-4%	-5%	-2%
Fulton	3%	-12%	-2%	-14%	8%	1%	-8%	-1%	2%	4%	-8%
Gwinnet	0%	-8%	-3%	-3%	-3%	3%	-6%	-2%	-3%	-3%	-3%
Henry	0%	-2%	-3%	-2%	-3%	1%	-2%	-3%	-2%	-3%	-2%
Rockdale	-2%	-2%	-3%	-2%	-3%	3%	-4%	-3%	-1%	-2%	-2%
Total	1%	-4%	-2%	-5%	-1%	0%	-6%	-1%	1%	-2%	-4%

Trip Distribution

One of the most powerful applications of the Census journey-to-work files is often in the validation of the regional work trip distribution model. While local home interview surveys can be useful in many aspects of model development, typically there is not enough data acquired to provide accurate estimates of trip distribution at the county level in an area the size of the Atlanta region, much less at the traffic analysis district or zone level. Normally such surveys for an area this size might contain 1,500 to 4,000 completed household records. The magnitude of the Census data make it particularly useful in this context.

Table 2 compares the trip distribution of the gravity model for Atlanta aggregated to the county level with a comparable distribution of trips extracted from the 1990 journey-to-work files for Atlanta and expanded by the factors suggested in this report. The maximum differences between the two distributions are in the range of 10 to 15 percent with the vast majority of the cells having differences of less than 5 percent. Clearly, the use of Census data is appropriate for this purpose, even if the total trips as derived from the Census are to be factored to match regional totals derived locally.

Note: The tables are arranged so that county name listed on the vertical y-axis of each table is in the same order for the x-axis which is not shown in the tables.

Mode Choice

Another valuable application of Census data could be the development, and/or validation of a region’s mode choice model. Unfortunately, it would appear to be in the area of identification of mode of travel that the Census journey-to-work data may be weakest. In most of the cities reviewed, there were significant differences between transit trips as reported by the Census and those reported by transit operating agencies, with substantial underestimates of transit ridership commonplace with Census data. The situation is even worse when estimates by transit submodes are considered. These problems are particularly apparent in the Atlanta area where regional bus trips appear to be greatly overestimated while trips on the regional rail system, MARTA, are underestimated.

Tables 3-1 through 3-3 provide a comparison of total transit trips for the Atlanta area, bus trips and rail trips, respectively, as derived from the Census journey-to-work files and expanded by the conversion factors suggested by this report, with totals as reported by on-board surveys completed by MARTA, the regional transit operator, supplemented by data from the Cobb County transit system. The comparison is quite disappointing. Total transit trips as reported by the Census and adjusted are 36 percent lower than those reported locally.

Part of this is to be expected and can be explained by the instructions in the Census to report a trip made by more than one mode as the mode on which the greatest time was spent. Thus a long drive access trip to a MARTA Rail station and a comparatively shorter rail trip would be recorded as an auto trip by the Census. That same trip would be reported as a transit trip in most urban planning models, including Atlanta’s.

The differences between these sources is even greater by submode. It appears that bus is substantially over reported while rail trips are under reported. Part of this can, again, be explained by the Census rule of reporting the mode on which one spent the most time on a trip using both bus and rail, but the magnitude of the differences cannot be accounted for entirely from this source.

Table 3-1: Regional Distribution
Atlanta Home-Based-Work Trip Productions - All Transit Sub-Modes

	Total Person Trip Productions Estimated from Census Data										
External	0	94	146	62	0	3	965	44	0	0	1314
Clayton	0	145	81	88	0	0	1198	26	0	0	1537
Cobb	71	83	888	36	0	0	1245	0	0	0	2323
DeKalb	258	545	507	9920	37	0	19437	417	0	12	31134
Douglas	16	0	12	0	25	0	100	0	0	0	154
Fayette	0	0	0	0	0	59	89	0	0	0	148
Fulton	304	1262	1381	6178	83	0	43571	492	0	37	53308
Gwinnet	60	18	10	45	0	0	1025	282	0	0	1441
Henry	12	11	0	14	0	0	38	0	68	0	142
Rockdale	0	0	0	14	0	0	36	0	0	50	99
Total	721	2157	3025	16357	145	62	67704	1261	68	99	91599

	Total Person Trip Productions Estimated From the Local Model										
External	0	0	0	0	0	0	0	0	0	0	0
Clayton	0	175	18	363	0	0	3582	24	0	21	4183
Cobb	0	49	0	391	0	0	1697	0	0	0	2137
DeKalb	0	1552	233	14100	0	0	34007	60	0	0	49952
Douglas	0	205	0	53	0	0	311	0	0	0	569
Fayette	0	0	0	0	0	0	0	0	0	0	0
Fulton	0	3885	1255	14423	0	0	64028	228	0	0	83819
Gwinnet	0	219	0	322	0	0	2614	0	0	0	3155
Henry	0	0	0	0	0	0	0	0	0	0	0
Rockdale	0	0	0	0	0	0	138	0	0	0	138
Total	0	6085	1506	29652	0	0	106377	312	0	21	143953

	Census Based Estimate - Local Model Based Estimate										
External	0	-94	-146	-62	0	-3	-965	-44	0	0	-1314
Clayton	0	30	-63	275	0	0	2384	-2	0	21	2646
Cobb	-71	-34	-888	355	0	0	452	0	0	0	-186
DeKalb	-258	1007	-274	4180	-37	0	14570	-357	0	-12	18818
Douglas	-16	205	-12	53	-25	0	211	0	0	0	415
Fayette	0	0	0	0	0	-59	-89	0	0	0	-148
Fulton	-304	2623	-126	8245	-83	0	20457	-264	0	-37	30511
Gwinnet	-60	201	-10	277	0	0	1589	-282	0	0	1714
Henry	-12	-11	0	-14	0	0	-38	0	-68	0	-142
Rockdale	0	0	0	-14	0	0	102	0	0	-50	39
Total	-721	3928	-1519	13295	-145	-62	38673	-949	-68	-78	52354

	Difference in Estimates / Local Model Based Estimate										
External											
Clayton		17%	-349%	76%			67%	-7%		100%	63%
Cobb		-69%		91%			27%				-9%
DeKalb		65%	-118%	30%			43%	-595%			38%
Douglas		100%		100%			68%				73%
Fayette											
Fulton		68%	-10%	57%			32%	-116%			36%
Gwinnet		92%		86%			61%				54%
Henry											
Rockdale							74%				28%
Total		65%	-101%	45%			36%	-304%		-373%	36%

Table 3-2: Regional Distribution
Atlanta Home-Based-Work Trip Productions - Bus Transit

	Total Person Trip Productions Estimated from Census Data										
External	0	84	121	52	0	3	610	35	0	0	905
Clayton	0	134	55	75	0	0	428	0	0	0	691
Cobb	43	83	880	28	0	0	860	0	0	0	1893
DeKalb	144	236	457	9292	37	0	12757	346	0	12	23281
Douglas	0	0	12	0	25	0	25	0	0	0	62
Fayette	0	0	0	0	0	59	37	0	0	0	97
Fulton	159	969	1234	5378	83	0	36040	359	0	37	44258
Gwinnet	26	0	0	40	0	0	127	258	0	0	451
Henry	0	11	0	14	0	0	19	0	68	0	112
Rockdale	0	0	0	14	0	0	36	0	0	50	99
Total	371	1517	2760	14892	145	62	50939	998	68	99	71850

	Total Person Trip Productions Estimated From the Local Model										
External		0	0	0	0	0	0	0	0	0	0
Clayton	0	0	0	0	0	0	0	0	0	0	0
Cobb	0	0	0	0	0	0	41	0	0	0	41
DeKalb	0	0	156	6492	0	0	5865	0	0	0	12513
Douglas	0	0	0	0	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0	0	0	0	0
Fulton	0	524	0	2565	0	0	11973	0	0	0	15062
Gwinnet	0	0	0	188	0	0	0	0	0	0	188
Henry	0	0	0	0	0	0	0	0	0	0	0
Rockdale	0	0	0	0	0	0	0	0	0	0	0
Total	0	524	156	9245	0	0	17879	0	0	0	27804

	Census Based Estimate - Local Model Based Estimate										
External		-84	-121	-52	0	-3	-610	-35	0	0	-905
Clayton	0	-134	-55	-75	0	0	-428	0	0	0	-691
Cobb	-43	-83	-880	-28	0	0	-819	0	0	0	-1852
DeKalb	-144	-236	-301	-2800	-37	0	-6892	-346	0	-12	-10768
Douglas	0	0	-12	0	-25	0	-25	0	0	0	-62
Fayette	0	0	0	0	0	-59	-37	0	0	0	-97
Fulton	-159	-445	-1234	-2813	-83	0	-24067	-359	0	-37	-29196
Gwinnet	-26	0	0	148	0	0	-127	-258	0	0	-263
Henry	0	-11	0	-14	0	0	-19	0	-68	0	-112
Rockdale	0	0	0	-14	0	0	-36	0	0	-50	-99
Total	-371	-993	-2604	-5647	-145	-62	-33060	-998	-68	-99	-44046

	Difference in Estimates / Local Model Based Estimate										
External											
Clayton											
Cobb							-1997%				-4518%
DeKalb			-193%	-43%			-118%				-86%
Douglas											
Fayette											
Fulton		-85%		-110%			-201%				-194%
Gwinnet				79%							-140%
Henry											
Rockdale											
Total		-189%	-1669%	-61%			-185%				-158%

Table 3-3: Regional Distribution
Atlanta Home-Based-Work Trip Productions - Rail Transit

	Total Person Trip Productions Estimated from Census Data										
External	0	10	24	10	0	0	355	10	0	0	409
Clayton	0	11	26	13	0	0	770	26	0	0	845
Cobb	28	0	7	9	0	0	386	0	0	0	429
DeKalb	115	309	50	628	0	0	6681	71	0	0	7853
Douglas	16	0	0	0	0	0	76	0	0	0	92
Fayette	0	0	0	0	0	0	51	0	0	0	51
Fulton	145	293	148	800	0	0	7531	133	0	0	9050
Gwinnet	34	18	10	5	0	0	898	24	0	0	989
Henry	12	0	0	0	0	0	18	0	0	0	31
Rockdale	0	0	0	0	0	0	0	0	0	0	0
Total	350	641	265	1465	0	0	16765	264	0	0	19749

	Total Person Trip Productions Estimated From the Local Model										
External		0	0	0	0	0	0	0	0	0	0
Clayton	0	175	18	363	0	0	3582	24	0	21	4183
Cobb	0	49	0	391	0	0	1656	0	0	0	2096
DeKalb	0	1552	77	7608	0	0	28142	60	0	0	37439
Douglas	0	205	0	53	0	0	311	0	0	0	569
Fayette	0	0	0	0	0	0	0	0	0	0	0
Fulton	0	3361	1255	11858	0	0	52055	228	0	0	68757
Gwinnet	0	219	0	134	0	0	2614	0	0	0	2967
Henry	0	0	0	0	0	0	0	0	0	0	0
Rockdale	0	0	0	0	0	0	138	0	0	0	138
Total	0	5561	1350	20407	0	0	88498	312	0	21	116149

	Census Based Estimate - Local Model Based Estimate										
External		-10	-24	-10	0	0	-355	-10	0	0	-409
Clayton	0	164	-8	350	0	0	2812	-2	0	21	3338
Cobb	-28	49	-7	382	0	0	1270	0	0	0	1667
DeKalb	-115	1243	27	6980	0	0	21461	-11	0	0	29586
Douglas	-16	205	0	53	0	0	235	0	0	0	478
Fayette	0	0	0	0	0	0	-51	0	0	0	-51
Fulton	-145	3068	1107	11058	0	0	44524	95	0	0	59707
Gwinnet	-34	201	-10	129	0	0	1716	-24	0	0	1978
Henry	-12	0	0	0	0	0	-18	0	0	0	-31
Rockdale	0	0	0	0	0	0	138	0	0	0	138
Total	-350	4921	1085	18942	0	0	71733	48	0	21	96400

	Difference in Estimates / Local Model Based Estimate										
External											
Clayton		94%	-42%	96%			79%	-7%		100%	80%
Cobb		100%		98%			77%				80%
DeKalb		80%	35%	92%			76%	-18%			79%
Douglas		100%		100%			76%				84%
Fayette											
Fulton		91%	88%	93%			86%	42%			87%
Gwinnet		92%		96%			66%				67%
Henry											
Rockdale							100%				100%
Total		88%	80%	93%			81%	16%		100%	83%

Clearly there is no substitute for locally derived transit data for the estimation or validation of a model capable of estimating modal choice. However, where an adequate on-board survey providing true origins and destinations of trips, not just station of boarding and alighting, is not available, the Census may be useful to provide a crude estimate of the distribution of trips. This distribution could then can be factored to an estimate of total linked home-based-work transit trips provided by local transit operators. If all else fails, the Federal Transit Administration Section 15 data source can supply estimates of total daily unlinked transit trips. Estimates of the percent all trips which are home-based work and the percent of transfers on the system can normally be estimated by the transit operator or derived from other similar transit systems nationally.

Note: The tables are arranged so that county name listed on the vertical y-axis of each table is in the same order for the x-axis which is not shown in the tables.

Conclusions

The greatest disparity for comparing the Census adjusted data to the local model data is based upon the inherent problems in the Census data. Because the Census asks for “typical/usual” data and “longest” mode, non-primary modes (transit) suffer from the adjustment and can only be assumed to be a best guess estimation. Comparisons for trip ends and trip distribution for total trips and auto trips proved to be close while the transit sub-modes had erratic results. The definition of the study region also plays a part in the disparities. Regions as defined by the traffic model versus Census boundaries can affect the number of trips used in the comparison. A third issue is the sample size that is available in any given stratification cell (1 auto-5 person households as an example) or distribution exchange (outlying zones-to-outlying zones) which tends to make these increments portray the greatest disparity in the comparison.

Preliminary comparisons have also been made using the Census adjusted data with locally developed model data in Hampton Roads, Virginia and Salt Lake City, Utah. Consistent with the Atlanta data, comparisons for total and auto for trip generation, trip distribution and mode split showed similar results to the Atlanta data set. Cells in the trip generation model with the fewest observations had the greatest differences. Locations with the fewest trip interchanges between zones in the trip distribution model showed the greatest differences. And sub-modes that made up less than 5% of the regional trip making also showed a poor comparison.

Adjusted census has been proven to be a valuable tool in the development of traffic model. For the calculation of cross-classification models or the review of trip distribution it can be as good as locally collected origin-destination data which is both costly and time consuming. Where the Census data falls short is in the analysis of mode. Reviewing the results indicate that Census is only reliable at the total trip or auto trip level. Other modes such as transit would have to rely on locally collected count data to validate transit trip estimates or locally calibrated mode choice models, which are costly, very time consuming and technically complicated.

Regional Level of Service Analysis Using GIS

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Abstract

Level of service (LOS) evaluation for a regional system of freeway and arterial roadways has traditionally created significant challenges for transportation planners. The regional roadway system consists of hundreds or even thousands of miles of roadway, so streamlined analysis methods must be applied. As a results, the analysis must usually rely on link volumes rather than intersection volumes. However, a standard link volume/capacity analysis does not reflect location-specific constraints which affect the level of service, such as terrain, signal spacing and timing, and side friction. And when future LOS is to be evaluated, forecast model results cannot be directly applied since regional traffic forecasting models are not sufficiently refined for forecasting traffic individual arterial streets.

A regional LOS analysis was recently conducted for over 1,200 miles of roadway in Western Riverside County, California. The area includes a population of 900,000 spread across 1,500 square miles on the eastern fringe of the Los Angeles metropolitan area, with development ranging from large areas of rural and semi- rural land to an urban core in downtown Riverside with a population density of over 7,000 people per square mile. The population is projected to increase to about 2 million by the year 2015, with much of the growth in suburban areas outside the City of Riverside.

The LOS analysis was conducted using a methodology developed by the Florida Department of Transportation. This method calculates a link LOS using several factors which reflect the specific conditions on individual streets: traffic volumes and peaking characteristics, roadway type, travel speeds, signalization characteristics, and degree of urbanization.

A Geographic Information System (GIS) was developed for the projects, and was used for post-processing the traffic model forecasts, determining several of the LOS factors and producing the LOS calculations. The GIS also provided LOS maps which could be readily understood by decision-makers.

The paper discusses how the Florida DOT method was applied to the regional analysis and how the GIS system was used to take the regional model's travel forecasts, conduct post-processing of model volumes, and prepare LOS estimates of roadways on the regional system.

Standardization of Life-Cycle Cost Analysis in Florida

Terrel Shaw and Greg Alford, Reynolds, Smith and Hills, Inc.; and Gary Sokolow and Doug McLeod, Florida Department of Transportation

Abstract

This paper will summarize the result of an effort prepared for the Florida Department of Transportation in standardizing life-cycle cost analyses performed for the Department. This effort was performed in response to the planning requirements of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the National Highway System Designation Act of 1995 (NHSDA). ISTEA required life-cycle costs to be considered as a factor in metropolitan and statewide planning. The NHSDA requires that a life-cycle cost analysis be performed for any investment in the National Highway System of $25,000,000 or more.

This study included (1) the analysis and documentation of existing software available for the economic analysis of transportation projects to life-cycle costing, (2) the development of a spreadsheet based software appropriate for systems planning and project planning applications, and (3) development of a handbook for the preparation of life-cycle cost analysis. The paper will present a summary of the assessment of existing software, including Microbencost (Texas Transportation Institute: 1994), HUCA (New York Department of Transportation: 1993) and BCR (Florida Department of Transportation: 1978). A summary of the input variables, application and use of the FDOT software and recommended practice provided in the FDOT Life-Cycle Cost Analysis Software will also be provided.

Current Practices in the Use of Multimodal Service Evaluation Standards at Public Transit Agencies

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Abstract

Service standards provide a transit agency with a mechanism to evaluate its service in an objective, consistent and equitable manner. During these times of shrinking operating budgets, services standards can provide the means by which limited resources are best allocated or reallocated. Another major objective of services standards is the design and implementation of new service.

This project was completed for the Metro-Dade Transit Agency (MDTA) in Southeast Florida. Its purpose was to review the current MDTA service planning guidelines to determine if more formal guidelines or standards should be adopted, develop an updated set of standards, test the new standards against existing service, and recommend a final set of standards and an implementation process. The standards were developed for each of the modes MDTA presently operates, and include Metrobus, Metrorail, Metromover, fixed-route paratransit service, and busway service.

An early step in the development of the service standards was to conduct a survey of peer transit systems across North America. The survey identified the existing levels of use of standards, including whether the standards are formally adopted, the process of implementing the standards, and their effectiveness in meeting the agency's goals. The advantages and disadvantages of formally adopting the standards were also examined.

The survey results uncovered passionate feelings for and against the use of strict standards among the agencies. In addition, those surveyed shared their strategies for persuading their governing bodies to adopt staff recommendations for service adjustments. These strategies included utilizing accurate, comprehensive data collection efforts, illustrating positive as well as negative effects of a proposed change, and emphasizing increased efficiencies. Another important strategy is to study all other options before recommending the elimination of transit service since, according to many of the agencies surveyed, standards should first be used as a diagnostic technique.

The public hearing and decision-making processes were also addressed in the survey. It was important to explore the relationships between transit planning staff, the agency's governing body, and the public, when potentially painful service charges are required. It seems best to have many public workshops, and to hold public hearings for input only and not decision-making. Also, it was suggested that agencies and their governing bodies work with committees to review proposed changes, and that proponents of service adjustments be invited to attend public hearings in addition to those who oppose the proposals.

The purpose of this presentation will be to describe the results of the peer survey and summarize the types of service standards currently in use throughout the transit industry in North America. In addition, CUTR will delineate the updated service standards developed for MDTA.

Accessibility by Design: Real-World Examples of Bus Stop Design

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Abstract

The bus stop is the first point of contact between the passenger and the transit service. The spacing, location, design, and operation of bus stops also have major impacts on transit vehicle and system performance. Thus, bus stop location and design are critical elements in the passengers' perception of transit service as a whole. Under the Americans with Disabilities Act (ADA) the idea of accessibility has been singled out for particular attention.

A recently completed Transit Cooperative Research Program (TCRP) project addressed bus stop design and accessibility. Based on a mail-out survey of 360 transit authorities (125 responses) and follow-up phone interviews (33 transit authorities), an interdisciplinary team made on-site inspections of over 270 bus stops in three states. Transit agency operations staff were also interviewed.

From this extensive data collection and field work, this presentation highlights real-world examples (as opposed to abstract dimensions and specifications) of a wide range of currently in-use design strategies for providing bus stop accessibility for the general public, as well as under the mandates of ADA. Examples include positive (successful) designs and treatments, as well as less successful designs. Common elements of successful designs and treatments are identified and discussed.

The examples and solutions illustrated are particularly relevant for anybody responsible for bus stop design and accessibility, including but not limited to ADA compliance.

Florida Five-Year Statewide Transit Development Concepts: A Policy Driven Planning Approach

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and Tara Bartee, Florida Department of Transportation

Abstract

Florida has taken a unique approach to planning in response to a stated transportation policy that defines a larger role for public transit in the state's future. The Florida Department of Transportation (FDOT) contracted with the Center for Urban Transportation Research (CUTR) to produce a concept plan that examines what that role might be. Florida Five-Year Statewide Transit Development Concepts breaks new ground in that it departs from traditional approaches to meeting transportation needs. Concepts is a policy- driven document, strategic in nature – not a plan that presents detailed, project-specific elements, but one that offers a range of possible alternatives for the future.

These alternatives are presented as six scenarios: the Trend Scenario projects a continuation of statewide transit growth; the Bottom-Up Scenario reflects local community desires; the Coverage Scenario establishes minimum geographic coverage and transit service levels for urbanized areas; the Modal Split Scenario targets increasing transit's share of local travel; the Corridor-Congestion Scenario defines transit needs to relieve congestion in major urban corridors; and the Peer Scenario outlines how Florida can keep up with other states.

This paper describes the policy and planning context under which Concepts was undertaken; the process of selection of the scenarios; a summary of the impacts of each scenario; and a discussion comparing the trade-offs between them. A discussion of basic assumptions precedes the reviews of the scenarios. Impacts including capital and operating costs, vehicle requirements, and anticipated changes in ridership are examined. The paper concludes with a discussion of how FDOT is using Concepts as it moves ahead to further develop a strategic public transportation plan, and a discussion of the potential applicability of this approach in other contexts.

The Center for Urban Transportation Research (CUTR), under contract to the Florida Department of Transportation (FDOT), set out to provide a rational way to characterize estimates of the need for public transportation that would be useful to policy makers. The project team, in consultation with the client, developed a concept plan which addresses needs in the context of six different scenarios. Each scenario was designed to address public transportation needs in terms of a particular goal for public transportation.

This paper summarizes the results of this conceptual study of statewide transit service needs. The study uses alternative scenarios for estimating needs and details the analytical approach for developing each scenario. The study, "Florida Five-Year Statewide Transit Development Concepts," is documented in a technical report and an Executive Summary. This study contributed to thought-provoking discussions of new ways to think about the role of transit.

The Policy and Planning Context

A major reexamination of what transportation is and what it is intended to accomplish has been taking place all across America over the past decade. The policies and practices of the past half century emphasized highway transportation. These policies and practices have been challenged as rising social and economic costs — evidenced by growing congestion, deteriorating air quality, and the decline of central cities — have extracted a heavy toll and led to a search for alternative approaches to meeting transportation needs. The overriding new approach has been to emphasize moving goods and people instead of vehicles, a recognition that various modes of transportation all have roles to play and that these modes need to be integrated into a functioning intermodal system. Transit can contribute to the intermodal system by providing basic mobility for persons who do not have other means of transportation and as an alternative to the automobile for those who have a travel choice. Societal benefits of reducing roadway congestion, improving air quality, decreasing fuel imports, slowing the demand for additional street and road capacity, and enhancing the mobility of those with limited travel options can all result from increased use of transit.

While not traditionally considered a strong transit market, Florida's extent of urbanization and the rate of growth provide a favorable setting for increased transit use. The lack of job concentration in downtown locations has made transit use for commuting less attractive in Florida than in many other states. A review of Florida's demographics reveals Florida urbanized areas (UAs) contain a lower level of non-whites than the U.S. (18 percent vs. 25 percent), and over 18 percent of all persons living in Florida's urbanized areas are age 65 and over. Florida is similar to the U.S. in poverty level and mobility limitation, with approximately 10 percent of households in Florida not having a vehicle available, compared to 14 percent in the U.S.

The concept of a new and broader role for public transportation is reflected in several legislative, policy, and program actions at the federal and state levels. The multimodal emphasis of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) epitomizes new trends in transportation policy thinking. The State's role in transit in Florida was expanded in 1989 with the creation of the Public Transit Block Grant Program, which carries with it the requirement that each recipient prepare an annual five-year Transit Development Plan (TDP). New directions have also been made clear in policy statements from the Florida Department of Transportation (FDOT) and the Florida Transportation Commission (FTC), which have emphasized public transportation as an alternative to the use of automobiles on Florida's highways and streets. Among the statements that have been expressed are the following:

- Florida residents and visitors should have travel options in addition to the automobile.
- Florida cannot build its way out of highway congestion solely by adding roadway capacity.
- Transit should play a greater role in meeting future transportation needs in Florida.
- Transportation and land use should be coordinated, and transit-oriented land use encouraged.

New policies in Florida support an enhanced role for public transit such as the FDOT policy to limit Interstate highways to a maximum of ten lanes, four of which will be exclusive lanes for use by high occupancy vehicles (HOV) including transit.

The Present Role of Transit Service in Florida

In 1993 nearly 173 million transit trips were made on the 19 transit systems that operate in 16 of Florida's 29 urbanized areas (UAs), plus the city of Key West. Local fixed route bus transportation is the backbone of transit in Florida. Rapid or heavy rail, commuter rail, and automated guideway modes are also represented. Demand responsive services are also offered to the general public by some transit operators. All transit systems are publicly owned and receive capital and operating assistance from local, state, and/or federal funds. Transit ridership has increased from 129 million trips in 1983 to over 173 million trips in 1993. Florida's transit systems operated 2,122 buses and 185 rail cars in 1993. These systems employed over 5,500 employees and had operating expenses in excess of $374 million. Per capita transit ridership in Florida urbanized areas lags behind other Sunbelt states like Arizona and Texas and is about one-third that of California and Georgia, ranging from 2.8 in Bradenton to 52.6 in Miami. Transit vehicles operate less frequently, over longer routes, and for fewer hours per day, providing less transit service per capita in Florida than in other states of similar demographic characteristics.

Defining Public Transit Cost Elements

Defining what public transportation is as it relates to the need study is a critical consideration. The Florida study discussed in the remainder of this paper did not include consideration of guideway investments. This reflected the fact that the time frame for the study was only five years, and the lowest cost basis for service expansion in Florida will most often be additional bus service. Other strategies for needs estimation might involve making determinations of whether or not to include guideway investments in the needs forecasts.

The Needs Scenarios

The study methodology involved constructing a series of six alternative scenarios, each based on a strategy for achieving a particular goal for transit. Each of the six scenarios is developed for the five-year period from 1995 through 1999. The strategy applied for each scenario is explained, as is the level of transit service to be provided, and the costs. Finally, a comparison is made between the six scenarios.

Four of the scenarios: Coverage, Modal Split, Corridor Congestion, and Peer, assume fundamental changes in the level of transit service supplied in Florida and set targets for such changes. The Trend and Bottom-Up scenarios do not assume fundamental changes in transit service levels. For the four target level-of-service scenarios (Coverage, Modal Split, Corridor Congestion, and Peer), basic assumptions include:

- The level-of-service increases are implemented uniformly during from 1995 to 1999.
- The only capital requirements are the costs of additional buses necessary to reach the target levels of service.
- The scenarios assume all increases in the supply of transit services will be in terms of fixed-route service and will occur in urbanized areas.

Scenario 1: Trend Scenario. This scenario extends existing statewide trends for operating costs, capital costs, number of buses, and passenger trips for Florida's transit operators through 1999. These projections are developed from Section 15 data on transit supply, passenger trips, revenues, and expenses for the years 1985 through 1993, and indicate what might be expected to take place if conditions remain the same as in the past nine years. Table 1 presents the capital and operating costs, number of buses, and passenger trips projected by the Trend Scenario.

The major strength of the Trend Scenario is its empirical basis and objectivity. A disadvantage is that specific transit system projections may become obsolete given a major change in an external

Table 1: Trend scenario projections, 1995-1999

Plan Year	1995	1996	1997	1998	1999	Five-Year Total
Operating Expense	$400	$420	$441	$461	$482	$1,880
Total Expense	$607	$562	$566	$567	$589	$2,477
Total Buses	2,217	2,285	2,353	2,421	2,489	n/a
Passenger Trips (millions)	175	180	186	191	197	n/a

Note: Costs in millions of 1993 dollars.

factor such as expansion of a transit system or the elimination of services to an area.

Scenario 2: Bottom-Up Scenario. This scenario consolidates local community needs and wishes as expressed through Transportation Development Plans (TDPs) developed for the 19 transit systems operating in urbanized areas and in Key West. FDOT requires each recipient of state transit assistance funds to prepare a five-year transit development plan. Local transit systems project needs and demand in their service areas.

Although local agencies are most familiar with the need and demand in their service areas, inconsistencies between TDPs exist because of various attitudes, goals, and objectives of the transit operators. For example, TDPs differ greatly between systems with expansion plans and those expecting to maintain the status quo. Because transit agencies are allowed great flexibility in determining local demand for transit, it is extremely difficult to produce meaningful statewide totals from individual TDPs. Nonetheless, the TDPs do indicate a magnitude of locally preferred services and what those might cost. This scenario presents the costs of attaining local desires and needs aggregated to the statewide level.

This scenario is particularly interesting in that it is both common as a means of estimating needs, and potentially controversial. Numerous advocates argue that the best indicator of need is the local constituency; and, that those who will use, operate and pay to support the transit service are the right audience to ask about needs. A broadly held perception of needs at the local level is probably a good indicator of the market’s willingness to support service. In an era where public participation in the planning process plays a role in shaping transportation policies and priorities, this method may result in plans well grounded in the pragmatic and political realities of the day. However, the bottoms up approach typically emanates from the transit community, and offers those with a vested interest in service expansion a major role in determining future needs. Table 2 displays the operating costs, capital costs, and number of buses as summed from the various local TDPs.

Scenario 3: Coverage Scenario. This scenario targets thorough transit coverage of Florida’s urbanized areas. The Coverage Scenario is based on the premise that to effectively penetrate the discretionary travel market, transit must offer the maximum opportunity for trips desired by an individual. This requires frequent service and good geographic and temporal coverage of the urban area.

Several assumptions have been made in developing this scenario. A minimum residential density of 3000 persons per square mile is generally recognized as necessary to support fixed- route tran-

Table 2: Bottom-Up scenario projections, 1995-1999

Plan Year	1995	1996	1997	1998	1999	Five-Year Total
Operating Expense	$564	$626	$672	$803	$877	$3,006
Total Expense	$1,182	$1,334	$1,392	$1,347	$1,391	$5,675
Number of Buses	2,427	2,671	2,897	3,117	3,300	n/a
Passenger Trips (millions)	198	224	249	274	300	n/a

Note: Costs in millions of 1993 dollars.

Table 3: Network coverage

Service Category	Population Density (Persons per square mile)	Network Coverage (Route miles per square mile)
I	3,000 - 5,999	12
II	6,000+	16

sit service (Pushkarev and Zupan). Another assumption is that people are not willing to walk more than 1/4 mile to a transit stop. Therefore, a hypothetical accessibility network is superimposed on those portions of each urbanized area where census tract population density exceeds the minimum threshold. To provide maximum transit options, the hours of service are standardized for all systems to a minimum 5:30 am to midnight service, seven days a week. The hypothetical network provides for minimum route coverage with ½ mile separations. As seen in Table 3, route density increases as population density rises from Service Category I (3,000 to 5,999 persons per square mile) to Service Category II (6,000+ persons per square mile). In service category two, off-peak route frequency increases to 15 minute headways from 30 minute headways in Service Category 1. Both service categories have 15 minute peak period headways.

Application of the Coverage Scenario involves constructing hypothetical transit networks for each urbanized area, determining the amount of vehicle miles needed to provide the service described above, identifying the number of buses needed to offer that service, and then calculating operating and capital costs (Table 4).

The major advantage of the Coverage Scenario is that it provides a standardized methodology for examining transit needs that can be applied to urban areas to establish a common level of service.

Table 4: Coverage scenario projections, 1995-1999

Plan Year	1995	1996	1997	1998	1999	Five-Year Total
Operating Expense	$655	$942	$1,251	$1,582	$1,939	$5,347
Total Expense	$979	$1,213	$1,502	$1,825	$2,188	$6,496
Number of Buses	2,632	3,142	3,652	4,162	4,672	n/a
Passenger Trips (mil.)	222	270	319	367	416	n/a

Note: Costs in millions of 1993 dollars.

Table 5: Modal Split scenario, high projections, 1995-1999

Plan Year	1995	1996	1997	1998	1999	Five-Year Total
Operating Expense	$454	$523	$597	$676	$760	$2,552
Total Expense	$682	$695	$746	$812	$899	$3,264
Number of Buses	2,282	2,442	2,602	2,762	2,922	n/a
Passenger Trips (millions)	193	213	233	253	273	n/a

Note: Costs in millions of 1993 dollars.

The target service levels are considerably higher than those currently offered by most Florida transit systems, but consistent with those provided in many other North American cities.

Scenario 4: Modal Split Scenario. A shift of travel from automobiles to transit is an important strategy in reducing congestion, improving air quality, and reducing the demand for additional roadway capacity. Implementing such a shift is the main goal of the Modal Split Scenario. The success of such a shift may be measured by the transit modal split—the percent share of person trips made by transit in a given area.

The Modal Split Scenario is based on the assumption that current transit modal splits are low in Florida; that they can be improved; and that improving transit modal splits can be done by establishing various targets and providing enough resources to attain those targets. At the urbanized area level, only 2.3 percent of Florida workers use transit as their journey to work mode. Higher population and employment densities, lower automobile ownership, higher level of transit services, historical trends, and other factors all contribute to transit mode splits.

A reasonable approach to increasing transit modal split is to set targets. Once targets are established it is possible to measure the number of vehicles and the amount of capital costs and operating expenses needed to attain those targets. This scenario established a range of targets for total travel and for the journey to work portion for each urbanized area: Low - maintain the current transit mode split, Middle - a 25 percent increase in transit share, and, High - a 50 percent increase over the current level.

Estimates of capital and operating resources necessary to attain the targets are provided for each urbanized area for the target year 1999 and totaled. Estimates of operating expenses are based on the person trips and the transit vehicle miles needed to attain target levels. For the journey to work, the number of peak period buses and their capital costs are estimated for the five-year period. Table 5 presents operating expenses, capital costs, and the number of buses necessary to attain the transit modal split targets by 1999.

A strength of this scenario is that it sets very specific goals for the mode share transit can be expected to achieve in an urbanized area. The scenario is consistent with FDOT's policy of an expanded role for transit and is also consistent with the emerging strategies for shifting travel from automobiles to transit. These policies are appearing in state and local transportation plans elsewhere—notably in Oregon, Washington, and in some urbanized areas in California. Uncertainty in attaining targets is the main limitation of this scenario. Even if the capacity is provided to attain the targets, there is no assurance the desired shift of travel from automobiles to transit would take place. Low density sprawl in many Florida urbanized areas is not conducive to transit use.

Scenario 5: Corridor Congestion Scenario. The goal of this scenario is to relieve congestion in Florida's urban corridors. A shift of travel from automobiles to transit is an important strategy in reducing congestion, improving air quality, and lowering the demand for additional roadway capacity. The scenario is supportive of FDOT policy statements promoting a greater role for transit. The Corridor Congestion Scenario provides a strategy for improving roadway level of service in critical corridors. The strategy is to increase transit capacity to allow a reduction in the number of automobile trips, thereby improving the level of service to an acceptable target.

Development of this scenario included the selection of the one or two most congested corridors in urbanized areas with such congestion. A total of 36 corridors from 23 urbanized areas were identified. Only roadway segments that are identified as congested (those operating at the level of service "F") were selected for analysis. For each selected corridor, the incremental transit service frequency was estimated so that the level of service along this corridor was increased to a minimum standard (level of service "D" for 34 corridors and "C" for the remaining 2) by 1999. Once the incremental service frequency was estimated, the incremental operating expenses were calculated and the number of buses and capital cost for the five years were determined for the selected corridors in the 23 urbanized areas, then summed to obtain a state total. Table 6 presents the cost estimates for phasing in the service level requirements over the five years of the plan.

A major benefit of this scenario is that it sets a specific goal for what transit can be expected to do in helping to secure the minimum level-of-service standard in congested corridors in urbanized areas. This scenario is consistent with FDOT's policy of an expanded role for transit in Florida's urban areas, and with emerging strategies for shifting travel from automobiles to transit. Similar to the mode split scenario, the main limitation of this scenario is that there is no guarantee that the desired extent of shift from automobiles to transit would take place.

Scenario 6: Peer Scenario. This scenario examines how Florida compares with other states in providing transit services, and how these are used. Comparison can help determine if an increased role for transit is a reasonable expectation. Experiences of other states may indicate if transit in Florida has maximized its potential, or whether additional investment in transit is needed. Examination of peer states demonstrates there is opportunity for expanded transit service, and information gleaned from the experience of others is used to develop a scenario to maximize that opportunity.

Table 6: Corridor Congestion scenario projections, 1995-1999

Plan Year	1995	1996	1997	1998	1999	Five-Year Total
Operating Expense	$688	$1,010	$1,356	$1,729	$2,129	$5,798
Total Expense	$995	$1,264	$1,591	$1,953	$2,360	$6,874
Number of Buses	2,663	3,114	3,565	4,016	4,467	n/a
Passenger Trips (mil.)	251	328	406	483	561	n/a

Note: Costs in millions of 1993 dollars.

Eight states were selected as "peers." Arizona, California, Colorado, Georgia, Texas, and Washington were carefully chosen for demographic characteristics, economic base conditions, and/or growth trends similar to Florida. Ohio and Pennsylvania reflect older urban patterns and have a longer, more continuous transit history.

The role of transit was examined through the use of Federal Transit Administration (FTA) Section 15 reports for 1992 and other material from the U.S. Census and the Nationwide Personal Transportation Survey (NPTS). Transit supply and utilization were examined in each of the nine states (Florida plus the eight peers) and all of the included census-designated urbanized areas. Transit supply includes network and fleet size, vehicle miles and hours, and other measures. Ridership is the principal measure of transit use. Costs of providing the transit service and farebox and other revenues are also considered.

The Peer Scenario is presented in two parts. The first is the comparative analysis of Florida and the eight peers at both state and urbanized area levels. This discussion begins with general demographic and other characteristics related to transportation and proceeds to the supply and use of transit. The second part develops a future scenario for Florida that might be achieved by offering a level of transit service approximating that of the peer states. Table 7 presents an overview of some of the general characteristics of Florida and the eight peer states. In comparison to the peer states, Florida ranks second in percent of population living in UAs, third in statewide population density, and first in autos per 1,000 population.

Transit supply shows considerable variation from state to state and among the urbanized areas in the nine states. The most obvious indicator of transit supply is simply the presence or absence of transit service. In comparison to the peer states, Florida has the lowest percentage of UAs provid-

Table 7: Peer state general characteristics

State	Population (millions)	# of UAs	Population in UAs (millions)	Population in UAs	Population Density	Land Area (sq. miles)	Annual Population Growth (1960-1990)	Annual Population Growth (1980-1990)	Population 65 and older	Population Below Poverty Level	Autos per 1000 Population
Arizona	3.7	3	2.7	72.9%	32.3	114,006	6.0%	3.5%	13.1%	13.5%	540
California	29.8	33	25.3	84.9%	190.8	163,707	3.0%	2.6%	10.6%	12.5%	560
Colorado	3.3	7	2.3	70.6%	31.8	104,100	2.9%	1.4%	9.8%	11.7%	640
Florida	12.9	24	10.2	78.7%	239.6	65,758	5.4%	3.3%	18.0%	12.7%	700
Georgia	6.5	10	3.3	51.2%	119.9	59,441	2.1%	1.9%	10.1%	14.7%	580
Ohio	10.9	16	6.9	63.3%	264.9	44,828	0.4%	0.0%	12.8%	12.5%	650
Pennsylvania	11.9	16	8.5	71.8%	265.1	46,058	0.2%	0.0%	15.1%	11.1%	540
Texas	17	32	11.3	66.6%	64.9	268,601	2.6%	1.9%	10.1%	18.1%	500
Washington	4.9	10	3.2	66.1%	73.1	71,303	2.4%	1.8%	11.9%	10.9%	590

Source: U.S. Department of Commerce, Bureau of the Census, 1990 Census of Population.

Table 8: Peer scenario projections, 1995-1999

Plan Year	1995	1996	1997	1998	1999	Five-Year Total
Operating Expense	$433	$479	$515	$557	$601	$2,198
Total Expense	$657	$647	$660	$689	$735	$2,894
Number of Buses	2,269	2,416	2,563	2,710	2,857	n/a
Passenger Trips (mil.)	180	187	195	202	209	n/a

Note: Costs in millions of 1993 dollars.

Table 9: Scenario comparison

Plan Year	1995	1996	1997	1998	1999	Five-Year Total
Total Expense						
Trend	$607	$562	$566	$567	$589	$2,477
Bottom-Up	1,182	1,334	1,392	1,347	1,391	5,675
Coverage	979	1,213	1,502	1,825	2,188	6,496
Modal Split	682	695	746	812	899	3,264
Corridor Congestion	995	1,264	1,591	1,953	2,360	6,874
Peer	657	647	660	689	735	2,894
Passenger Trips (millions)						
Trend	175	180	186	191	197	n.a.
Bottom-Up	198	224	249	274	300	n.a.
Coverage	222	270	319	367	416	n.a.
Modal Split	193	213	233	253	273	n.a.
Corridor Congestion	251	328	406	483	561	n.a.
Peer	180	187	195	202	209	n.a.

Note: Costs in millions of 1993 dollars.

ing transit service. Per capita transit trips are compared at both the statewide and urbanized area levels. Overall transit use in Florida is lower than in the peer states.

The second part of the Peer Scenario is the development of a transit future in Florida that raises the level of service to that of the peer states. Increasing vehicle revenue miles (VRMs) per capita is the service factor used to bringing Florida’s public transportation service to peer state levels. Capital costs were estimated based on the number of additional buses necessary to raise Florida’s VRMs to peer state levels. Operating costs were estimated by multiplying the cost per vehicle revenue mile by the required additional VRMs. (Table 8).

Comparing the Options

A comparison of costs, number of buses, and passenger trips is presented in Table 9. The operating costs associated with sustaining any of the scenarios beyond 1999 should be recognized as 1999's operating costs plus an adjustment for inflation. Additional capital costs would be required beyond 1999 for replacement of buses and facility improvements. The comparisons in costs are also shown in Figure 1.

Conclusions

The strategy followed in Florida provides a variety of ways of thinking about the needs for public transportation in Florida. The different scenarios give the reader an overall feeling of the magnitude of costs that would be required for public transportation to fulfill a larger role in Florida. This document is not a plan, but a tool for considering how different policy decisions might affect the role of transit in Florida's near-term future. The presentation of these scenarios and their related costs reflect new ways of thinking about the role of transit. Each scenario offers a particular concept for consideration as decision makers weigh transportation options. The methodologies respond to the expanded set of goals set for public transit investments and explores needs in the context of this expanded goal set.

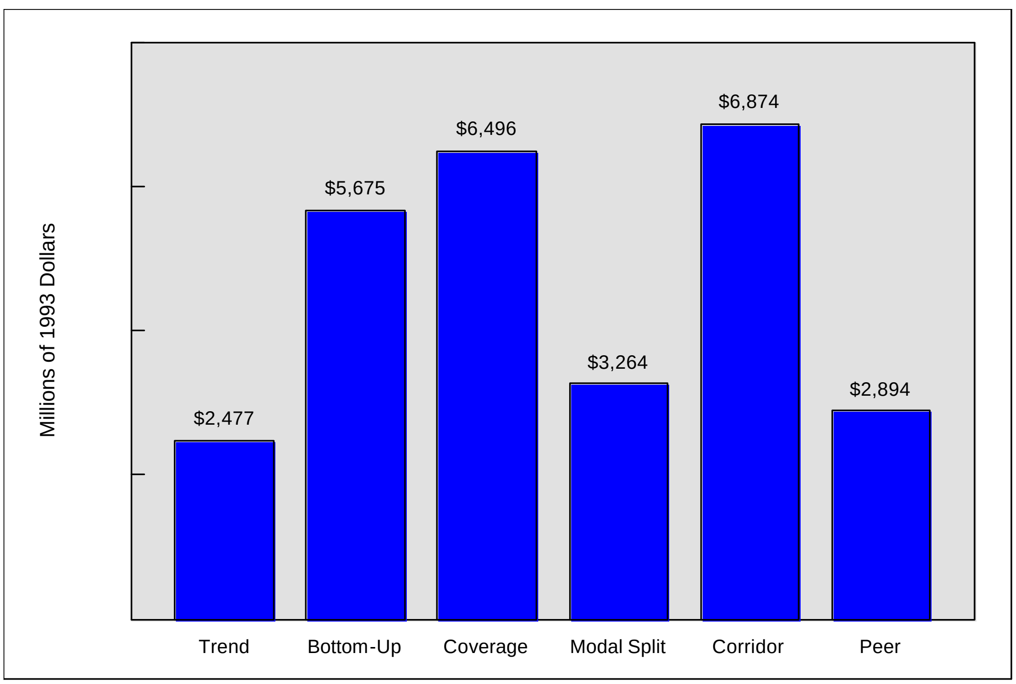

Figure 1: Scenario comparisons

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Examining Transit Services in the Detroit Area: A Spatial Perspective

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Abstract

Like many other major metropolitan areas nation-wide, Detroit has experienced significant suburbanization. Facing a sprawling environment, two major local public transit providers, Detroit Department of Transportation (DDOT) and Suburban Mobility Authority for Regional Transportation (SMART), reviewed and modified their operations in order to cut back unnecessary expenditures while maintaining desired levels of service. For instance, both transit agencies started operating small shuttle buses with more flexible routes and schedules, or providing demand-respond paratransit services.

Geographic Information Systems (GIS) technologies, in conjunction with a transit on-board survey conducted in October 1995, are used to examine transit service performance from a spatial perspective. The fixed- route public transit services within the tri-county metropolitan area evaluated based on several accessibility measurements, such as population, employment, no vehicle household, etc. The 1990 Census Transportation Planning Package (CTPP) data is used to illustrate the spatial distribution of potential transit demand. Several applications were developed to aid transit agencies to evaluate different components of their operations. Such applications include buffering and integration of highway and transit data.

The DDOT 1995 on-board survey data is geocoded by Traffic Analysis Zone (TAZ) and analyzed spatially. For example, the highest ridership origin-destination pairs are identified and displayed using GIS so that transit providers can adjust their services, if necessary. Finally, GIS is used to further explore the spatial characteristics of the on-board survey data by developing several ridership forecast models. The legitimacy of using some traditional indicators, like population and employment, for predicting potential transit demand is discussed. It is hoped that the study results can be a valuable reference for transit providers to better predict transit demand by using existing information, such as CTPP.

Planning Lee County's Variable Pricing Program

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Abstract

Congestion (or variable) pricing can be described as the charging of more for goods or services during periods of peak demand. In theory, this practice would prove beneficial when setting fares on toll roads and bridges. However, in practice it has proven extremely difficult to implement in the United States. This paper examines many of the planning issues and solutions found during the early phases of a variable pricing pilot study currently being conducted in Lee County, Florida.

The planned variable pricing scheme is detailed, along with how this publicly and politically palatable pricing scheme was derived. Data collection efforts, which include origin/destination surveys, focus groups, mail back surveys, video taping of traffic, and detailed traffic counts are described to emphasize the substantial effort undertaken to obtain accurate and meaningful variable pricing data that can be applied across the country. The paper concludes with a summary of work done to date and an overview of the next steps towards implementation of the variable pricing program in Lee County.

The practice of charging higher prices for a commodity during times of peak demand is common in many industries, for example telephone rates increase during peak periods. This pricing scheme enables commodity providers to regulate usage and attempt to flatten out the peaks and valleys in the demand curves. In theory this is an equitable and efficient form of pricing, but application has proven difficult in toll roads and toll bridges across the United States.

Despite the fact some transportation providers, such as airlines, have used variable/congestion pricing schemes for years, variable road pricing is proving extremely difficult. Several countries have successfully instituted variable pricing (most notably Singapore) but several factors have delayed or stopped variable pricing in the United States. This paper examines the initial steps in one of the possible variable pricing success stories in the United States, the Lee County variable pricing program.

United States Efforts in Congestion Pricing

In recent years the United States has made several attempts to introduce variable pricing to highways and bridges. The Federal Highway Administration's (FHWA) Congestion Pricing Pilot Program choose its first project in 1993. The San Francisco-Oakland Bay Bridge project was to lead the way for other congestion pricing projects in the US, but the state legislature refused to allow the bridge toll to be raised from $1 to $3 during peak periods. The efforts to install variable pricing on this bridge have reverted to feasibility and background studies.

The FHWA has funded six other pre-project studies in Minneapolis-St. Paul, Los Angeles, Portland, Boulder, New York, and Houston. However, there is no money under the pilot program to fund these projects past the study phase. There is money to fund two other projects to implementation, a high occupancy vehicle (HOV) buy-in project in San Diego, and a variable toll project in Lee County, Florida. In addition to these two projects, State Route 91 in California and the Maine Turnpike have already instituted congestion pricing programs.

At the same time, the general public is being introduced to congestion pricing through focus groups, surveys, and in one case, a citizens jury. During the summer of 1995 the Humphrey Institute for Public Affairs at the University of Minnesota conducted an intense five day citizens jury on the topic of congestion pricing. Twenty-four citizens were exposed to the concept, the benefits, and the disadvantages, through testimony from industry experts. Despite the fact this event was held in an area without toll facilities, the jury's responses proved insightful. To summarize, the jury voted against the use of congestion pricing to raise revenues for transportation. The main reasons for this vote were that congestion pricing:

- would not result in a change in driving behavior;
- is an inefficient way to raise revenues; and
- is a regressive tax system.

The National Research Council also examined congestion pricing (Special Report 242). This report was written by industry experts and compiled a vast amount of data available on tolls. Their findings included:

- Depending on the level of peak period fees applied, some motorists would change their driving habits. Using data from past toll increases at toll facilities and parking lots the researches estimated that an increase of $2.00 to $3.00 per daily round trip would reduce peak period congestion by 10 to 15 percent. This would depend heavily on numerous factors such as alternate routes, alternate modes of transportation available, and the demographics of the area's population.
- The shifting of 10 to 15 percent of drivers from the peak period would result in a net benefit to society. The benefits derived from the time saved by the remaining peak period drivers would outweigh all disbenefits of such a system.
- Some individual motorists would lose under any variable pricing scenario. Although a great deal can be done to try to ensure very few motorists feel they have been inconvenienced (such as using the congestion toll collected to improve transit) some will inevitably be disadvantaged.
- Air pollution would be reduced.
- A major stumbling block to implementation is the political feasibility of congestion pricing. Lee County's variable pricing program uniquely addresses this issue as tolls will not be increased during the peak hours, but reduced during the times just before and after the peak period. This has the support of the politicians in the area and has been viewed favorably by residents in focus groups.
- It is critical to gather data on early congestion pricing programs to provide careful analysis of results. To convince additional areas to attempt congestion pricing there needs to be hard data on the success of the program in the few trial sites.

Thus the focus is now on implementing, and carefully analyzing, several congestion pricing pilot programs. The analysis of how travel patterns were altered, how citizens reacted, how politicians reacted, etc., will be shared so that other areas will have evidence of the benefits of congestion pricing. This will inevitably be a slow process (serious emphasis and money has been focused on congestion pricing since 1993 but only two projects have succeeded in implementing some form of variable pricing with Lee County soon to become the third. Gathering ample data on these few projects will be crucial to the success of variable pricing in the U.S.

Lee County Characteristics

Lee County currently has two toll bridges (Sanibel Island Causeway and Cape Coral Bridge) with a third toll bridge (the Midpoint Bridge) to open in November of 1997. The current toll collection system allows payment via a bar code sticker system or by cash. With the bar code sticker system, patrons have several payment options — making the entire tolling system somewhat complex. At the Cape Coral and Midpoint Bridges the toll is $1, charged in each direction, unless the user has purchased a discount sticker. At the Sanibel Bridge the toll is $3, charged in one direction only, unless the user has purchased a discount sticker. Users can also purchase two forms of discount stickers to be placed on their side windows. The expensive version of these stickers allows the user to pass the toll plaza toll-free for one year. The less expensive option allows the user to pay a discounted toll ($0.50) every time they drive through the plaza for one year.

A laser reads the bar code on these stickers to identify the vehicle and determine the toll to be paid. However, the sticker system has a high percentage of misreads and there are numerous "misread days" during the year, particularly in winter. Environmental conditions along Florida's coast cause a great deal of condensation on vehicle's windshields, causing the optical scanners to have difficulties reading the stickers. Due to these problems Lee County is upgrading their system using newer electronic toll collection (ETC) technologies.

TransCore (formerly Syntonic) was chosen to integrate ETC with the traditional toll collection equipment. TransCore then selected Amtech to supply a Radio Frequency Identification (RFID) system with toll plaza readers and vehicle transponders. The transponders (or tags) will be "off the shelf" Amtech technology. This benefits Lee County in several ways, it is a known and widely used technology and most problems with the devices have already been eliminated, transponders are available now, and SunPass (Florida's Turnpike's ETC system) also chose Amtech to supply tags allowing for greater interoperability.

To estimate the potential benefits of ETC, and to determine the optimum toll plaza configuration for the ETC equipment, computer simulation modeling of the toll plazas will be performed. This effort will help the Lee County DOT to determine which lanes should be dedicated ETC lanes, mixed use lanes (with both ETC and automatic coin machines), and manned lanes. It will also help to optimize the entire operation, as some manned lanes may not be needed as many patrons will be using ETC. This is a critical part of the ETC installation planning process.

Data Collection

Not surprisingly, peak levels of traffic and congestion occur during the winter months, with the peak being in March. This being tourist season, a great many more vehicles are on the road. Furthermore, few of these vehicles are equipped with the bar code sticker to allow for faster processing at the toll plaza. This puts an added strain on the manual toll lanes that already have the longest queues year round. Since the peak traffic is in March, all pre- variable pricing traffic data collection was done during this month. The following is a summary of the data collected to date:

- Origin/Destination Surveys were completed for Sanibel, Cape Coral, Caloosahatchee, and Edison Bridges (the latter two are untolled bridges in the area). Data was obtained for an eleven to twelve hour period on a week day and a weekend day, on each bridge. Responses were coded into analysis zones and an Origin/Destination table for each bridge was prepared.

- Approximately 8,000 bridge user surveys were distributed in conjunction with the Origin/Destination survey outlined above. The survey included questions relative to potential transponder usage, as well as congestion avoidance behavior. Approximately 2100 surveys were completed and returned, a typical response rate for this type of survey. The following details some of the more interesting results of the survey done on the Cape Coral Bridge:

Questions regarding current toll payment method:

Do you currently have any type of toll sticker?
Yes: 37%   No: 63%
Does the sticker give you:
a 50 cent toll per trip?: 72%   no toll per trip?: 28%

Questions regarding transponder usage:

How likely is it that you would obtain a transponder for use at the toll facilities?
very likely: 29%   somewhat likely: 24%   very unlikely: 47%

How important is it that the transponder be transferable between vehicles?
very important: 44%   somewhat important: 23%   not important: 33%

Would you pay more if the transponder were transferable between vehicles?
a) Yes, if no more than 25 cents extra per trip: 3%
b) Yes, if no more than 10 cents extra per trip: 8%
c) Yes, if no more than 5 cents extra per trip: 7%
d) No: 82%

Compared to the toll you are now paying, would you be willing to pay an additional amount for the convenience of using a transponder?
a) Yes, if no more than 25 cents extra per trip: 3%
b) Yes, if no more than 10 cents extra per trip: 9%
c) Yes, if no more than 5 cents extra per trip: 9%
d) No: 79%

If you used a transponder would you prefer to handle billing by:
a) Pre paid account: 17%
b) Automatic deduction from checking or credit card account: 10%
c) Pay a monthly bill similar to electric or water bill: 73%

Questions regarding variable pricing:

If a reduced toll were offered outside of rush hour could you change the time you make:
a) Almost all of your rush hour trips: 27%
b) Some of your rush hour trips: 32%
c) Almost none of your rush hour trips: 41%

To persuade you to make the trip outside of rush hour, how much of a savings would have to be offered?

a) 10% savings:	4%
b) 25% savings:	21%
c) 50% savings:	41%
d) Greater than 50% savings:	34%

- Time/Delay studies were completed over 18 primary commuter routes, most of which included bridge crossings. These routes were traveled a minimum of two times in each direction during peak travel hours.
- Congestion video tapes were made utilizing seven complete video systems at thirteen sites. A total of 142 video tapes were made for use as qualitative baseline archives.

The survey results indicate economics is a prime consideration in all aspects of this project. Respondents wanted the ability to transfer the electronic toll collection (ETC) tag between vehicles so that they could get the reduced price on more than one family vehicle. The question on whether they would pay more for the convenience offered by ETC was met with a resounding "no." The responses from this survey, and in the focus groups, showed a strong dislike and distrust for any form of automatic debiting system. For variable pricing to be effective at least a 25 percent, if not a 50 percent, decrease in the toll rate is necessary. These results will be used extensively when attempting to market the new ETC devices and the variable pricing program.

In addition to this data, Lee County has an impressive traffic count program and an additional origin/destination survey was performed in 1993. To obtain citizen reactions to both variable pricing and ETC many focus groups were convened. The first set of focus groups was held in March 1996. A total of 6 groups were convened with eight to ten members in each group. The groups consisted of employers, commuters, retirees, and students. The principal findings of these focus groups were:

Once explained, the idea of ETC was almost universally accepted.

- The idea of variable pricing as an abstract concept was generally acceptable if it were implemented as a discount to the existing toll structures.
- The level of discount necessary to induce a significant diversion was at least 25 percent, and more likely 50 percent.
- As anticipated, persons with limited amounts of time available were more receptive to variable pricing and ETC. Retiree and student population appeared to be the least interested.
- Strong resistance to allowing a governmental agency to automatically debit checking or credit card accounts was encountered.

A second set of focus groups was held at the end of July 1996. The groups were similar to the first session, but the participants were new. The focus of these sessions was citizen reactions to the various possible variable pricing scenarios.

One important result from the July focus groups is a strong negative reaction to the concept of variable pricing in general. When participants first hear an explanation of the theory, they immediately oppose it, most often on the grounds it would penalize the worker who does not have a

Congestion on Cape Coral Bridge

flexible schedule. However, when participants were informed of Lee County's variable pricing plan (where tolls are not raised, but reduced in off peak hours) the groups response shifted 180 degrees, and they were in favor of such a system. From these limited encounters it is clear that variable pricing will meet with a great deal more success if it is offered as a carrot (monetary incentive to travel outside the peak periods) rather than a stick (penalize those traveling during the peak periods).

Other focus group findings are listed below:

Variable Pricing

1. When groups were first introduced to variable pricing, it was defined as paying more to travel across the toll bridges during peak periods and less in the off-peak periods. This initially produced a strong negative reaction. Participants felt this concept was unfairly charging the working class, who do not have flexibility in their schedule and must drive during peak periods. In addition, almost none of the participants had heard of variable or congestion pricing before.

2. The proposed variable pricing scheme for Lee County was then introduced. This pricing scheme involves no toll increases, only toll decreases, during set periods of time both before and after the morning and evening rush hours. Once participants learned of Lee County's specific variable pricing plans, they reacted very positively to variable pricing. Participants understood how this might reduce congestion during the rush hours.

3. Participants felt that it would require at least a 50% reduction in tolls during discount hours for the program to be successful. At this level many felt that some of the tourists, retired people, and others who do not have to be on the road at peak times of the day may be enticed to travel during the discount periods instead.

Electronic Toll Collection

1. Participants views varied considerably on ETC, but the majority saw ETC as a better toll col-

lection method than the current bar code reader system.

2. There was little correlation between those participants accustomed to electronic devices (ATM cards, computers) and those that have heard of ETC or those who enthusiastically wanted to use it.

3. Participants wanted the purchase of ETC tags and accounts to be as easy as possible for themselves. They wanted to have several different ETC tag purchasing methods available. The following methods were most often mentioned:

    - phoning in their tag order and receiving the tag through the mail.
    - picking up the tag at the tax collectors office — similar to how the stickers are distributed now.
    - purchasing the tag at a small store or booth in a shopping mall.

4. There were many questions on the accuracy and reliability of the ETC tags, the possibility of tag theft, enforcement in ETC lanes, and what happens when an account runs low or is empty. After explaining how accurate the tags are, the fact that the tag is encoded with your individual information and using a stolen tag would immediately pinpoint the thief, the use of video enforcement systems, and how other ETC systems take care of low accounts, participants were generally impressed with the technology.

5. Participants felt that the gates should be removed from the ETC lanes. They cited the fact that it would slow users down — and the purpose of ETC was so that users could drive through the toll plaza quickly. It was explained that gates can be very high speed and could allow for high speed travel, but it was still felt that the sight of gates would be a deterrent to people choosing ETC since it appears to be just as slow as the old method. They also thought that gates may prove to be a hazard.

6. Participants overwhelmingly favored tags that can be easily transferred between cars. They did not view them as significantly adding to the number of trips made across the bridge and felt that they would only transfer the tag between cars occasionally.

7. Many participants saw a great advantage to ETC in that record keeping would be made easier. They liked the idea of a monthly statement to keep track of their toll charges or for employee reimbursement.

    - Participants wanted choices as to how to replenish their accounts. Several methods mentioned repeatedly, included:
    - automatic charge on a credit card.
    - automatic charge to a checking account.
    - mail in a check.
    - pay cash at a convenient location.
    - an automated phone line which you can use to transfer money between a bank account and an ETC account.

8. Participants were generally not concerned with the fact that using one of these ETC tags gives the government the ability to automatically identify your vehicle (the “big brother” issue). This may be due to the fact that these residents are accustomed to having identification tags (bar code stickers) already.
9. Participants were not concerned with any possible detrimental health affects from the ETC system. No mention or questions arose with regards to possible health hazards (there are no known health hazards from ETC).

The Variable Pricing Options

Lee County’s program has been termed variable pricing, and not congestion pricing, as it is significantly different from typical congestion pricing toll structures. The primary difference is that tolls are decreased in the time periods adjacent to the peak times, instead of simply raising the toll during peak periods. However, only two of the three bridges are being examined for this variable pricing toll structure. For several reasons the Sanibel Bridge toll structure will not be examined in depth for variable pricing. These reasons include:

- the peak period on this bridge occurs from 10 A.M. to 1 P.M., not in the traditional peak times. If traffic were induced into traveling outside of these hours it is likely that traffic in the 7:00 A.M. to 9:00 A.M. time frame would increase. Employers on the island feared that this would hinder their employees commute to work.
- citizen concerns that an increase in the toll could hurt the retail industry on the island;
- the large amount of tourists who would be unaware of the variable pricing program;
- the primary road on the island is a two lane facility that is already congested. Residents feared that a reduction in the toll rate on the Sanibel Bridge (which is the only road access to the island) at any time of day would exacerbate traffic problems on the island and lead to reduced toll revenue.

This leaves the Cape Coral and Midpoint Bridge’s toll structure to examine. These two bridges will be examined together since bonding covenants require the toll structure on the bridges to be identical.

There are two critical issues shaping the variable pricing toll structure for these particular bridges. The first is that the Board of County Commissioners (BOCC) has promised the citizens that the tolls will not increase on the Cape Coral or Midpoint Bridges. The second is that to collect meaningful data, the fare structures before and after variable pricing is implemented must be similar. This creates a challenge since Lee County’s current toll system can be described as anti-congestion pricing.

The toll structure in place encourages frequent users to purchase either the reduced price sticker or unlimited pass sticker. The average toll paid by these users (annual cost of the sticker plus the price paid per trip, all divided by the average number of trips per year for that vehicle class) is 64 cents for the reduced price sticker and 61 cents for the unlimited pass sticker. The regular toll is $1 for two-axel vehicles. The majority of frequent users are undoubtedly commuters who travel during peak periods. Therefore, peak period users are now paying the least to use the bridge, and to shift a large percentage of these commuters from the peak, without raising tolls, will be difficult.

In order to avoid raising tolls and attract users to off peak periods, Lee County has decided to reduce tolls in off peak hours. However, reducing tolls during all off peak hours would result in substantial revenue loss. The loss would exceed the seven million dollars set aside for compensation for lost tolls under the congestion pricing pilot program.

Due to these factors the following variable pricing scheme has been brought forward:

- only ETC patrons will be eligible for the toll discount. This was done for several reasons including the fact that residents are much more likely to use ETC than visitors and residents can be better informed and educated about the variable pricing program. Secondly, it reduces the number of vehicles given the discounted toll, as vehicles that just happen to arrive during discounted hours, but do not have ETC, must pay full fare. In this manner the program targets and educates the frequent users to actually change their habits.
- Discount hours are limited to: 6:30 A.M. to 7:00 A.M. 9:00 A.M. to 11:00 A.M. 2:00 P.M. to 4:00 P.M. 6:30 P.M. to 7:00 P.M. This was also done to target a specific group of commuters to shift their driving patterns. Discounts for all hours of the day and night except peak times were not given as this would not focus on the desired effect of spreading out the peak.
- Discounts will be 50 percent.

From all early indications, this pricing scenario is acceptable to the public, politically acceptable, is financially feasible, and will successfully entice drivers to travel during the shoulder periods (those times adjacent to the peak periods).

Summary and Conclusions

Lee County has done a great deal of preparation work and study towards implementing a successful variable pricing program on two of their toll bridges. The plan has the support of local politicians and the public, thereby overcoming two of the major stumbling blocks to implementation. Focus group responses and results from a bridge users survey have helped a great deal in the formulation of an acceptable variable pricing toll scheme. However, a great deal of work is yet to be done, including marketing, ETC procurement and installation, public education, and post implementation data gathering. Plans to perform all of these tasks are being discussed to ensure the continued success of this variable pricing program.

Findings From the Evaluation of 40 LACMTA TDM Demonstration Projects

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Abstract

The Los Angeles County Metropolitan Transportation Authority (LACMTA) has funded over 120 TDM Demonstration Projects to identify the cost-effectiveness of these strategies in reducing congestion and emissions. Currently 40 TDM demonstration projects, 28 with quantifiable impacts, have been evaluated by a third-party and by the staff of the LACMTA. The evaluations have closely followed a methodology developed by COMSIS Corporation that quantifies both the transportation and air quality impacts as well as calculates the project's cost effectiveness.

This paper will summarize the major findings of this large number of TDM projects representing a wide variety of project categories including a variety of shuttle services, vanpool programs, financial incentives and disincentives such as parking pricing, telebusiness centers, child care centers linked to transportation services, bicycle facilities at transportation terminals, and other programs designed to encourage ride sharing, transit use, and other alternative travel modes to single occupant vehicles.

This paper is significant to the transportation planner because it represents the compilation of a large number of TDM demonstration projects using the same methodology. Although the projects evaluated are for customized applications in the Los Angeles region, the findings should be useful to the practitioner in developing successful public agency TDM programs and standardized evaluation methodologies.

The (First Generation) Michigan Statewide Truck Travel Forecasting Model

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Abstract

A prototype statewide truck travel forecasting model was developed as part of an update of Michigan's statewide travel model and databases. A hybrid model was specified which combines elements of mode- abstract regional commodity flow models with mode-specific truck models. This presentation will describe the model development process and components.

Because of the high volume of commodities moving between Canada and the U.S. through Michigan, separate models of domestic and international flows were created. Flows through the border crossings were estimated using truck interview and Canadian trade statistics. The domestic model includes a truck trip generation submodel coupled with a two-stage destination allocation submodel. The truck trip generation model used rates and equations derived from the 1983 Commodity Transportation Survey. The 1983 Commodity Transportation Survey data was supplemented with locally collected truck survey data and input- output commodity consumption coefficients to develop the destination allocation model at the county level. A synthetic technique was used to further allocate the flows to traffic zones within each county for network assignment.

The presentation will conclude with an overview of ongoing model enhancement initiatives, which include the incorporation of more recent Michigan truck survey data, the 1993 Commodity Flow Survey, and regional input-output multipliers. A rail-truck diversion model under development will be described, as well as lessons learned from the first application of the model in north central Michigan.

An Integrated Transportation-land Use Model For Indiana

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Abstract

Despite the recent research interest in integrating land use and transportation models inspired by federal legislation, no product had met the data, budget, and personnel constraints faced by the metropolitan planning organizations in Indiana. Consequently, the Indiana Department of Transportation sponsored a study to determine the feasibility of assembling a software package that would capture the relationships between land use and transportation that MPOs need to incorporate in their planning and analysis, while accounting for the current and expected status of Indiana MPO hardware and software capabilities. An Integrated Transportation Land Use Modeling System (ITLUMS) was developed by adapting standard land use models in the literature to the needs of Indiana MPOs. In addition, ITLUMS automates procedures that have been done manually and offers some new methods for key steps in the modeling process. ITLUMS was developed with the close participation of an MPO, whose data were used to calibrate, validate, and test the system. The results were satisfactory enough to justify proceeding to the implementation stage of the project.

The application of land-use/transportation models has evolved over two decades. The Clean Air Act Amendments (CAAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 have accelerated this evolution. The CAAA demands that air quality forecasting must consider the interaction between land use and transportation and requires regional land use policies for mitigating congestion and environment impacts. The ISTEA requires long range transportation plans to quantify impacts on land use. For example, MPOs in non-attainment areas need to indicate whether new transport projects will have negative impacts on air quality.

Background

Land use planning in Indiana has been primarily a manual process. Planners at most of the MPOs in the state have met with key groups and individuals in their community. These participants typically generate several growth scenarios, then pool their experience, expertise, and judgment to determine likely future land use patterns by consensus. Software packages that perform some or most of this land use forecasting and allocation process are out of reach of most MPOs in Indiana. This is so for the following reasons:

- *Expense*. Many of the MPOs in Indiana are just beginning to acquire the hardware and software needed to install geographic information systems (GIS). The substantial additional cost of the more well-known land use models is not compatible with the budgets of most Indiana MPOs.
- *Black boxes*. Many of the land use models are run by their developers, who produce an answer or set of answers for the MPO/customer. MPOs would prefer to have control of software, whose constituent algorithms and processes they understand.[1]
- *Data hungry*. Even if the previous two problems are overcome or neglected, many land use models require data that exceeds the amount of data routinely collected by Indiana MPOs or does not match the type of data they collect. Is it safe to assume that models built on data such

as “basic” and “non-basic” employment can be used with employment data categorized as retail and non-retail?

Research questions

In response to the issues raised in the previous section, the Indiana Department of Transportation (INDOT) commissioned researchers at Purdue University to investigate the feasibility of making available to the MPOs in Indiana a land use allocation model suitable for their needs. The subsequent research project had as its basic initial focus three important questions:

1. Can the land use allocation processes currently used by Indiana MPOs — or acceptable alternatives — be automated?
2. Can land use and transportation planning models be integrated into a process that is compatible?
3. Is the resulting process affordable - in terms of hardware, software, data, and personnel effort?

The research was guided by certain constraints. (1) The literature search was conducted with an awareness of what data were available to MPOs, or could be acquired by them with reasonable effort. (2) Any software developed to implement an integrated model ought to be compatible with the travel demand modeling package TRANPLAN. INDOT had acquired a statewide license for TRANPLAN and made it available to all the MPOs in the state. (3) Although few MPOs had an active GIS capability as the research started, INDOT was beginning to use GIS and certain low-price GIS packages were becoming available. Could the integrated model be implemented with a low-price GIS package?

Major ITLUMS Components

Because its objective was to assemble an easy-to-use package that would integrate standard land use allocation and travel demand models, the study began with a search through the literature for elements that would meet the specific needs and limitations of Indiana MPOs. The result of the study was the Integrated Transportation Land Use Modeling System (ITLUMS) illustrated in Figure 1. ITLUMS consists of three main components:

1. *A Land Use Allocation Module*. This module is based on a Lowry-Garin Gravity Model. It includes residential and employment location models in the Lowry-Garin tradition, but begins with two land use potential study techniques (described below) and employs a microeconomic-based land consumption model. It was also found to be both convenient and efficient to accomplish the trip generation and trip distribution steps of the travel demand analysis for home-based work and shopping trip within this module.
2. *A Travel Demand Module.* This module uses TRANPLAN to accomplish trip generation and trip distribution for the trip types not addressed in the Land Use Allocation Module. It also completes the remaining steps in the standard four-step transportation modeling process.

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1. The authors of this paper confess to having their primary backgrounds in transportation planning. After hearing them make their “black box” remark in Dearborn, a subsequent speaker — whose primary expertise was in land use modelling — said that travel demand models could also be accused of being “black boxes.” The authors acknowledge this riposte.

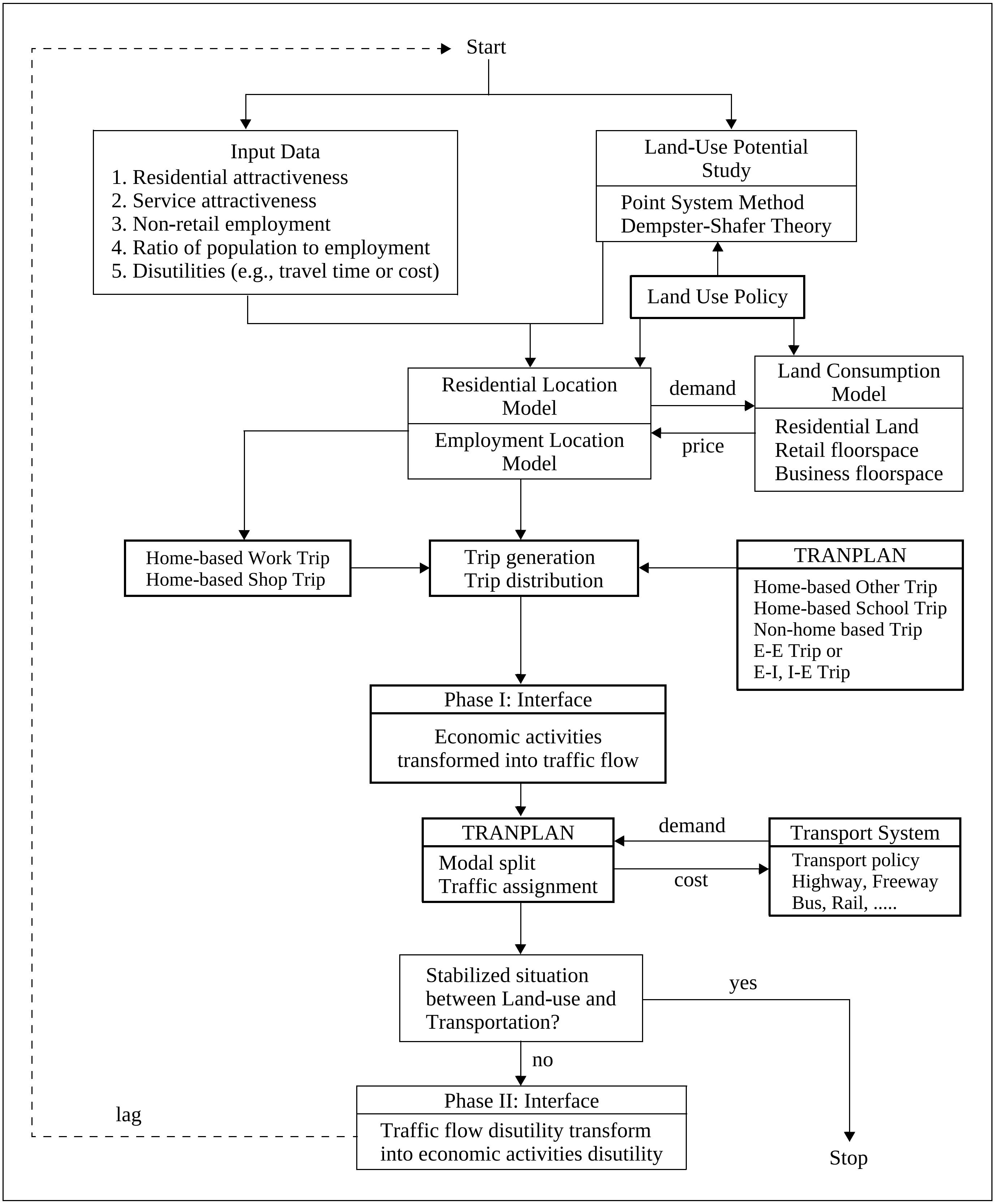

Figure 1: ITLUMS framework

3. *Interface Modules.* The Phase I Interface Module in Figure 1 translates the economic activities that result from the Land Use Allocation Module into input for the Travel Demand Module. The Phase II Interface Module facilitates the feedback from transportation back to land use. Phase II incorporates a time lag for the response of land use to changes in the transportation system.

The "flow" in Figure 1 is followed for a given time period until a stable solution is reached.

Land Use Potential Study

The land use allocation process begins with (a) projections for the expected population and employment for a given year and (b) information about the current and potential use of land in the study area. The study described here borrowed from a "point system" for assessing land use suitability that has been used by Lafayette, Indiana's Area Plan Commission (APC). The Point System uses eight factors to determine how suitable a land area is for five land use types. The eight factors used in this study were soil productivity, soil stability for construction, flood plain status, degree of forestation, distance to utilities, distance to highways, distance to airport and railroad, and current land use. The five land use types are residential, industrial, commercial, agricultural, and open space. Using GIS and a simple FORTRAN code, the study automated the Point System calculations that the APC has done manually. In the process, an alternative to the Point System, based on Dempster-Shafer evidence theory, was also implemented.

The Point System and Dempster-Shafer land indexing methods offer different ways to assess the suitability of land for given uses. When the automated Point System method was applied to Lafayette area data, the resulting GIS plot of land use potentials closely resembled the long-range land use plan developed by APC with its conventional methods. When Dempster-Shafer was used, the plot was very much like APC's phased land use plan. These results were very encouraging to both the APC participants in this study and to the researchers. While these two methods automate the land use potential study, there is a significant cost in terms of the data preparation required. It was decided in this study that land should be divided into 16 cells per square mile in rural areas and into 36 cells per square mile in urbanized parts of the study area. For each such cell in a study area of, say, 400 square miles, entering data on eight factors as they pertain to five land uses can lead to thousands of data entries. Fortunately, much of this information is becoming available in GIS-compatible format. For example, soil conditions and highway networks can be imported into GIS layers that allow automated determination of an individual cell's soil and highway accessibility ratings. The land use potential study is a critical early step in the ITLUMS. It allows for a greater degree of consistency in seeking the appropriate uses of land in a community.

ITLUMS Model Calibration and Validation

Although the Lafayette study area had approximately 10,000 land use cells and 210 traffic analysis zones, experimentation showed that aggregating these units into the county's thirteen townships provided the best basis for calibrating the model to historical data. Township data on population, housing units, and retail and non-retail employment for 1980, 1990, and 1993 were used to estimate ITLUMS parameters pertaining to trip lengths, dwelling units, rent, retail employment density, travel costs, etc. Calibrating the model for three different years indicated an adequate level of stability in the parameters, except where there were explainable trends in their values.

To validate the calibration results, the calibrated model was used to convert APC future-year values for demographic and economic values into land use patterns. Because ITLUMS incorporated expected transportation changes into its forecasts and the APC did not, a direct comparison of the forecasted land use patterns could not be made. However, the direction and magnitude of the differences between the ITLUMS and APC forecasts were deemed acceptable by the APC. In addition, ITLUMS would undergo further tests using scenarios of special interest to the APC, providing further opportunities to assess the value of ITLUMS as a planning tool.

Policy Tests

At the present time, northbound US Highway 231 enters downtown Lafayette from the south, turns west and crosses the Wabash River into West Lafayette and passes through the Purdue University campus. Currently under construction is a relocated alignment of US231 several miles to the west. No longer will through northbound traffic on US231 or traffic destined for Purdue have to travel through downtown Lafayette. Given the potential for increased accessibility from southern Tippecanoe County to Purdue, what will be the impacts on land use patterns in the county? The purpose of Policy Test 1 of ITLUMS was to answer this question. The results, according to ITLUMS, was an acceleration of growth in population and retail employment just south of Lafayette. In the City of Lafayette itself, population decline would continue more quickly, but retail employment would be helped. The transportation components of ITLUMS indicated the degree to which reduced congestion on old US231 permitted better travel times to activities in and near downtown Lafayette. Elsewhere, population and employment expected rates of growth were not significantly affected by the relocation of US231.

Just east of Lafayette, Interstate Highway 65 connects Indianapolis and Chicago. To the east of I65 is an area of rapid commercial and residential growth. A large new residential subdivision is planned for the south part of this growth area. Whereas Policy Test 1 looked at the land use impacts of a major change in the transportation system, Policy Test 2 reversed the nature of the question: What will be the impacts on the transportation system of a particular land use change, namely, the completion of a large new subdivision? The ITLUMS results quantified the degree to which levels of service on the road network east of I65 would be further degraded, and the benefits to be derived from additional capacity on SR26 and from an additional bridge across I65 to Lafayette.

The highway network change in Policy Test 1 involved a new road facility that ended at Purdue University. Beyond Purdue, existing roads would have to be used. What would be the impacts of extending the current US231 project beyond Purdue to the northwest quadrant of Tippecanoe County? This question became the basis for Policy Test 3. The results showed that few changes in land use would take place because of an extended US231 project. This is because other factors were more important than travel time in decisions that affect land use. Whereas the results of Policy Tests 1 and 2 showed a possible tendency for ITLUMS to be too sensitive to changing inputs, the results of Test 3 demonstrated that ITLUMS can take into account other factors in the land use decision process. While the results of Policy Test 3 were surprising to APC and the researchers, they were explainable and actually enhanced the credibility of the ITLUMS.

Conclusions

While the development of an Integrated Transportation Land Use Modeling System (ITLUMS) for Indiana MPOs has been largely successful, several concerns remain. The positive aspects of

ITLUMS are:

- It uses data available to Indiana MPOs.
- It automates several procedures that have been heretofore carried out manually with great tedium.
- The land use potential indexing methods encourage an objective and consistent approach to relating an area's characteristics to its best land use type(s).
- Its results were verified and endorsed by the participating MPO, whose data were used.
- It facilitates the analysis of alternate scenarios, increasing the planner's ability to anticipate problems associated with proposed development or transportation projects.
- Although ITUMS was developed using a full-scale GIS package (TransCAD), it was shown that ITLUMS can be implemented using Maptitude, a software package currently selling for about $400.

The difficulties in using ITLUMS are:

- Manual entry of data for the land use cells can be extensive, unless the appropriate data are available in a format compatible with ITLUMS software.
- Determining appropriate land use suitability values, especially for the Dempster-Shafer method, requires practice.
- The Interface Modules in ITLUMS still involve manual tasks, such as editing output files from one module to produce input files for the next module.
- There may be a tendency for ITLUMS to exaggerate land use impacts of transportation changes, although Policy Test 3 demonstrates that this is probably not a serious problem.

The last stages of the ITLUMS project involve making implementation as convenient as possible. ITLUMS has already been demonstrated to interested Indiana MPOs, but the Interface Modules need to be automated and/or simplified. An implementation report in the form of a step-by-step user's manual is being prepared.

Note

This paper is based on the applications-oriented presentation made at the Sixth Transportation Planning Applications Conference in Dearborn, Michigan on 21 May 1997. A paper with a detailed description of the model has also been prepared. Later in 1997, the final report of the research report will be available from the Joint Transportation Research Program at Purdue University. The paper and/or the report can be obtained by contacting Prof. Fricker.

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The SMART Model: A New Tool for Statewide Planning, Programming and Air Quality Analysis

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Abstract

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Clean Air Act Amendments of 1990 (CAAA) created new requirements regarding the use of analytical tools in statewide planning, programming, and air quality analysis. Many state departments of transportation have struggled since the passage of these two acts to find the appropriate tools to meet these new requirements. ISTEA required statewide transportation plans for the first time, and mandated that metropolitan transportation plans and improvement programs be consistent with the statewide plan. Further, the act stipulated that such plans and programs be developed in consultation with metropolitan planning organizations (MPOs) and their member agencies. Because long range plans and transportation improvement programs must also be fiscally constrained, the development of plans and programs at a metropolitan and state level has requirement significantly more technical analysis, time and other resources, before adoption than plans and programs developed prior to the passage of ISTEA.

For the Illinois Department of Transportation (IDOT), COMSIS adopted a methodology developed by the University of Illinois in Chicago that simultaneously forecasts trip distribution, mode choice and assignment in a “combined” model using a single set of speeds that achieves the best fit for the model system as a whole. The driving purpose was to provide IDOT with expanded travel demand analysis capabilities that are consistent with available regional data and travel demand modeling practices while maintaining quick turnaround and ease of use. The adopted methodology has been implemented in a Windows-based package called the Simplified Method for analysis of Regional Travel (SMART) that employs an aggregate (sketch planning) zone structure in conjunction with detailed regional zone and network information available from existing data sources. The SMART model also contains a regional emission analysis element that allows for the assessment of mobile emissions resulting from forecast travel volumes and speeds, making it a fully- capable regional travel analysis tool. The entire SMART model, including travel analysis (distribution, model choice, and assignment) and emissions assessment, can be run overnight, allowing for rapid analysis and evaluation of a wide range of projects and programs. IDOT has recently started using the SMART model to test individual projects or groups of projects for their regional travel and emissions impact prior to including them in long range plans and transportation improvement programs in the Chicago region.

Review of Land Use Models: Theory and Application

Kazem Oryani, URS Greiner, Inc. and Britton Harris, University of Pennsylvania

Abstract

In this paper we will discuss our methodology in reviewing land use models and identifying desired attributes for recommending a model for application by the Delaware Valley Planning Commission (DVRPC). The need for land-use transportation interaction is explored, followed by a synthesis of inventory of land use models for agency use. This is followed by an overview of three operational land use models.

Details of three operational models — DRAM-EMPAL (S. H. Putman), MEPLAN (Marcial Echenique) and METROSIM (Alex Anas) — are explored in terms of model formulation and special features. In order to draw on the main factors in implementation, we conducted detailed telephone interviews with five major Metropolitan Planning Organizations (MPOs) who use land use models. These interviews were performed as part of our work for the enhancement of DVRPC's travel simulation models in 1996.

A two-step model selection and implementation process is proposed. The recommendation is that limited versions of the above three modes be acquired for prototype use, policy analysis and impact assessment. The final selection will be based on objective performance of the models using a similar battery of tests on the same data sets.

The Need for Land Use Models

This paper is based on our report for the Delaware Valley Regional Planning Commission (DVRPC) to review land use models as part of the DVRPC's on-going effort to enhance their travel simulation models. DVRPC's model enhancement effort has twelve tasks. The land use model review is the task for which we had direct responsibility.

DVRPC is the MPO serving Bucks, Chester, Delaware and Montgomery counties as well as the City of Philadelphia in the State of Pennsylvania plus Burlington, Camden, Gloucester and Mercer counties in the State of New Jersey. In total, DVRPC covers eight counties in two states and the City of Philadelphia. The commission's predecessor agency was the Penn-jersey Transportation Study during 1959-1964. DVRPC was created in 1965.

Our report for DVRPC contains Appendix B, a parallel paper written by Britton Harris for the study, which traces development of the land use model from the historical perspective with respect to theories underpinning these models.

What is the function of land use models or more precisely what does the Transportation-Land Use Interaction model do? Land use models deal with describing activities of land consuming actors and their competition for land in an urban setting. These actors are households, firms and retail establishments, each with particular requirements for space and access to jobs, schools and markets. Describing the spatial distribution of these activities at present and projecting future land uses are the main two aspect of these models. These models also consider interaction among these activities through the transportation network.

Land use transportation interaction models overcome the deficiencies in the existing traditional four-step models. Consider the addition of a new facility in a metropolitan area. As the result of the addition of this facility, there will be some route changes, even possibly some mode switching and possibly some destination changes where travelers can satisfy, say, their shopping trip needs. What the existing transportation models are not capable of capturing is the projection of relative changes in household location and employment location of the land consuming actors.

The reason for the deficiencies of the existing traditional four-step transportation models is that land use activities considered in the trip generation phase have a fixed spatial pattern. It is known that improving transportation facilities or even anticipation of a new transportation facility creates a secondary effect. These changes in population and employment location are due to the fact that some of these zones in the study area become more accessible and therefore households and firms start to relocate to take advantage of the new facility, even anticipating these changes. These secondary effects are not considered in the traditional four-step transportation models.

In traditional land use planning, the future transportation system is also assumed to be fixed, while the increase in population or activity in zones might require further facility enhancement. However, often these are not considered in the assumed transportation network which is being used for land use projection.

Over time, this disjointed planning framework creates imbalances between transportation and land use. The imbalances show themselves as congestion, overloaded networks in some part, and under-utilized facilities on the other. Famous examples of these imbalances are the overloaded Shirley Highway in Washington, DC or the London Orbital Highway in England. These facilities became prematurely overloaded few years after their opening. Ordinarily these highway were assumed to have a 30-year service life-span.

Not all imbalances show themselves in congested facilities. Under-utilized facilities such as the Sawgrass Expressway built by the Broward County Expressway Authority in Florida is the other side of the imbalance. The Sawgrass Expressway when opened in 1986, realized only a portion of the traffic projected on the facility.

These and many other examples show that there is a need for feedback between land use and transportation models.

As Harris explains in appendix B of the DVRPC report, modern research on housing choices, and other aspects of urban form theory, began with Wingo (1961) and Alonso (1964) books in which they explain that people in different income classes compete for residential land, and considering a monocentric employment city, locate in concentric rings as densities decline going away from the employment center. Locators are trading longer commutes and higher transportation costs for added space and amenities. In this formulation, all members of a household class behave identically, which in reality is not the case.

Modeling urban form, as represented by location (land use) models, was initiated by Lowry in his Model of Metropolis (1964). Lowry considered the City of Pittsburgh, where the location of steel mills and other large industries, because of their size requirement and distant markets, are independent of local employee location. These were considered as basic employment. The model is based on the assumption that, everything else being equal, the place of employment determines the place of residence. Place of work (basic employment location) implies the place of residence (population and dwelling units). The resident population requires “services”, therefore, place of service employment is determined by resident population. The service employees themselves require housing in relation to their place of work. This additional population requires further services which will be fulfilled by additional service employment. The new service employees require housing in relation to their place of work. This round of reasoning continues until there are very few service employees or households to be located.

Households and employment are constrained by regional employment and household totals. The heart of the model for placing households is a gravity model relating homes to employment using an impedance function of power form. One of the derivatives of Lowry's model is the Time Oriented Metropolitan Model (Crecine, 1994) which introduces an element of time in the model. The original Lowry formulation, as Lowry himself puts it, generates an "instant metropolis" (Lowry 1964).

Wilson (1967, 1970, 1971) introduced principles from information theory to estimate a typical trip table which is used to create a series of spatial interaction models. DRAM, a reformulation of the Projective Land Use Model (PLUM, Goldner 1968, in Putman, 1979), is based on the use of the explicit determination of a trip table using Wilson's maximum entropy formulation. A more detailed description of Putman's model and associated flowchart will follow in section III.

The MEPLAN model of Marcial Echenique and Partners (Planning and Design, 1994) introduces elements of relative rent for land (comparative prices) as a market clearing mechanism. The model uses an economic input-output method to describe the flow of activities over the transportation network. Relative cost of transportation (including congestion) is used in reallocation of land uses. A more detailed description of Echenique's model and associated flowchart will follow in section III.

Others efforts in modeling urban form have used optimization theory. These models assume the pattern of household and employment locations can be described as allocations of new land uses in such a way as to optimize an objective function which consists of transportation costs and activity establishment costs. The models have constraints intended to ensure that zones are not filled beyond capacity and that all activities are allocated. Technique for Optimum Placement of Activities into Zones (TOPAZ) uses a non-linear objective function (for more detail see Oryani 1987). It is one of a small number of optimizing models which have been used by planning agencies to define extremes of alternatives.

The Herbert-Stevens (1961) model attempted to simulate market conditions for redistributing locational choices. It based its formulation on the economic theory of trading time for lower densities and other amenities in suburban development. This model was extended by Harris (1963) and Wheaton (1974) to form a model in which a non-linear adjustment of bid rents cleared the market.

It was not until the NBER (Ingram 1972) model that multiple employment location was considered. The model considers housing preferences in locating the household, and deals with housing conversion and redevelopment. As Harris explains in Appendix B of the DVRPC report, in reality transportation planners and geographers did know that people locate themselves in such a way that similar households do indeed behave differently and thus require the use of some form of the gravity model.

Wilson's work on gravity models had pointed out that there were essentially three formal types —

unconstrained, singly constrained, and doubly constrained. Trip distributions are doubly constrained, so that trips and opportunities are balanced at zones of departure and arrival. It can be shown, although it is not widely recognized, that the “balancing factors” in this model have an economic significance with regard to locational advantage which is analogous to the dual variables in linear programming, as in the NBER model. The original Lowry model and most of its successors were, however, singly constrained: the trips originating at the place of employment were exactly distributed, but the arrivals at residential destinations were uncontrolled, and excess arrivals which could not be accommodated with available land were arbitrarily redistributed. Even when this model was doubly constrained, the economic significance of the constraints was not adequately recognized.

This difficulty began to be overcome in the early 1970s. Echenique (for a review of his work see the Journal of Planning and Design, 1994) working with the larger model systems discussed in the next section, recognized the need for constraints in the Lowry Model which he had been using, and made the key innovation of using land or housing rents as the constraint. It now seems obvious that well-located or well-designed residential precincts, which attract unusual numbers of residents, can charge higher prices or rents, and that it is precisely these user costs which prevent the areas from actually becoming overcrowded. This is exactly the way in which market-clearing models operate, but in this case the idea of rents was applied in a model which did not have uniform economic behavior, but rather the dispersed behavior of the gravity model. At about the same time, coming from the Wingo-Alonso-Mills school of economic models, Anas (1975, 1987) introduced discrete choice behavior into models with economically specified behavior and market clearing.

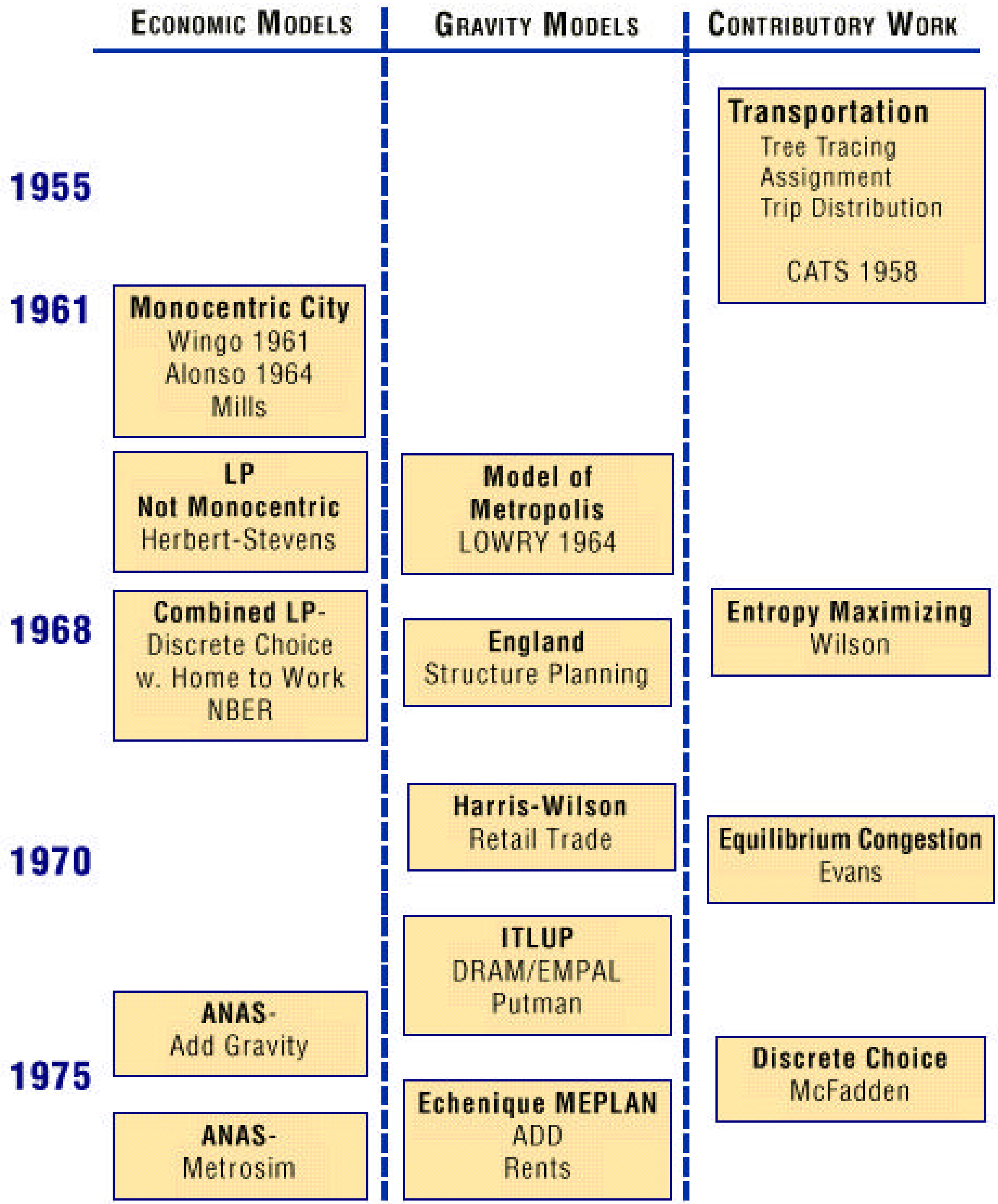
These approaches, from opposite schools of residential modeling, effectively unified ideas of market clearing and dispersed behavior to provide for realistic modeling of the residential land and housing market.

Similar modeling of retail trade and service location (for example, Harris and Wilson, 1979) and industrial location have begun to solve somewhat less difficult problems. These activities taken together lay the basis for large-scale unified models of metropolitan growth and function.

Putman (1971, 1983) deserves recognition as the first to clearly emphasize in publications the importance of this final integration. His subsequent work has built on the Lowry model and has recently introduced new methods for dealing with industrial location. Echenique has continued to pursue his revision of the Lowry Model, and has for many years emphasized the importance of transport and transport modeling in his work. Anas has undertaken several modeling efforts dealing with all of these issues, from a more or less rigorous economic viewpoint, with transportation inputs. His models of industrial location are less complete than those of Echenique, and his transportation modeling is not at the level of most transportation planning agencies. Putman has only recently begun to introduce constraints and product differentiation in his housing models.

This discussion has emphasized the work done by only three individuals and their associates, since they have played key roles in the development of the field. Echenique has some students who have produced models on their own account, and Putman has a few practitioner-students using and developing his models in US agencies. These three individuals and a few of their students are the only sources for commercially available integrated models.

SHORT HISTORY OF URBAN MODELS



Inventory of Land Use Models

In a demonstration project to develop methodologies for evaluating alternative land use patterns for air quality implications by the Organization of 1,000 Friends of Oregon, the following fourteen land use models were identified:[1]

1.	TOPAZ	Australia
2.	MEP	U.K.
3.	ITLUP (DRAM-EMPAL)	U.S.A.
4.	LILT	U.K.
5.	AMERSFOORT	Netherlands
6.	CALUTAS	Japan
7.	IRPUD (Dortmund)	Germany
8.	OSAKA	Japan
9.	SASLOC	Sweden
10.	MEPLAN	U.K.
11.	TRANUS	Venezuela
12.	TRACKS	Australia
13.	TRANSTEP	Australia
14.	TOPMET	Australia

Most of the above models are not available commercially for agency use. Available models include TOPAZ, TOPAZ82, MEPLAN, ITLUP, TRANUS, TRACKS and TRANSTEP. Among the available models only ITLUP (DRAM-EMPAL), MEPLAN, and TRANUS have sufficient installation sites to enable users to share experiences to shorten the learning curve in modeling applications.

A survey of MPOs covering the twenty largest Metropolitan Statistical Areas in the United States, and two additional agencies known to be on the leading edge of model use was made by the same 1,000 Friends of Oregon study. Information about land use data and land use procedures in travel demand modeling was provided by nineteen of these twenty-two agencies.

The survey found that eight agencies use land use data in the traditional form in trip generation. None of these “traditional” agencies had a land use model for allocation of development activities to zones.

A second group of five agencies, called innovative by the Oregon study, used land use allocation models to provide input data to the trip generation phase of their transportation models. Except for one agency which used its own specific technique, the other four agencies utilized DRAM-EMPAL models.

The third group included four agencies which are in transition from “traditional” to “innovative” approaches in land use data. Except for one agency, which is in the process of creating its own land use model, the three other agencies are in different stages of implementing DRAM-EMPAL as their land use model

1. Source: “Making the Land Use Transportation/Air Quality Connection”, Volume 1, October 1991 prepared for the Organization of 1,000 Friends of Oregon, Cambridge Systematic, Inc., with Hague Consulting Group

The fourth group consists of two agencies. One uses a variant of DRAM-EMPAL models integrated into transportation modeling with necessary feedback mechanisms between the transportation and land use models. The other agency, the Association of Bay Area Governments, has created its own land use model, POLIS, which is described below.

A more recent inventory of operational models is made by Wegener (1994) entitled “Operational Urban Models: State of the Art”. The following twelve models are identified as being operational. He made no judgements on the quality of the models, but the criteria of being applied to real cities and being operational had been satisfied:

1. POLIS: the Projective Optimization Land Use Information System developed by Prastacos for the Association of Bay Area Governments
2. CUFM: the California Urban Future Model developed at the Institute of Urban and Regional Development of the University of California at Berkeley
3. BOYCE: Combined models of location and travel choice developed by Boyce
4. KIM: the non-linear version of the urban equilibrium model developed earlier by Kim et al.
5. ITLUP: the DRAM-EMPAL Integrated Transportation and Land Use Package developed by Putman
6. HUDS: the Harvard Urban Development Simulation developed by Kain and Apgar
7. TRANUS: the transportation and land-use model developed by de la Barra
8. 5-LUT: The 5-Stage Land Use Transport Model developed by Martinez for Santiago de Chile
9. MEPLAN: the integrated modeling package developed by Marcial Echenique & Partners
10. LILT: the Leeds Integrated Land-Use/Transport Model developed by Mackett
11. IRPUD: the model of the Dortmund region developed by Wegener
12. RURBAN: the Ransom-Utility Urban Model developed by Miyamoto

In a later paper by Wegener (1995), the following model is added to the above list:

13. METROSIM: the new microeconomic land use transportation model by Anas

The most recent Survey of Land Use and Travel Data of the Metropolitan Planning Organizations of the 35 Largest U.S. Metropolitan Areas by Porter (1995) contains information about land use forecasting procedures and the use of land use models. According to this survey:

- Twelve MPOs are using DRAM-EMPAL models
- Five MPOs are using their own models (POLIS, PLUM, and three local models)
- One MPO is in the process creating its own model
- Two MPOs use the Delphi (exchange of expert opinion) Technique

Fifteen agencies do not use land use models but use qualitative procedures. This group allocates land use to TAZ on the basis of forecasts of population and employment.

Methodology for Selecting a Land Use Model

Many of the models mentioned were one time applications at a single city. We decided that the model should be commercially available, be operational, be used in multiple locations and be theoretically sound.

With these criteria, our list of models were reduced to three models:

DRAM-EMPAL (S. H. Putman Associates)

MEPLAN (Marcial Echenique Associates)

METROSIM (Alex Anas)

A brief description of each model and their associated flow-chart follows:

DRAM (Desegregated Residential Allocation Model) is a singly constrained Lowry-derivative model which forecasts household location in relation to employment and probability of work trips between zones.

The work trips probability has two components: Travel impedance and measure of attractiveness of the zone for household location. The attractiveness measure uses the following variables:

1- Vacant, build able land in origin zone

2- Percentage of buildable land which is not already built

3- Residential land

4- Percentage of household in the lowest income group

5- Percentage of household in the low middle income group

6- Percentage of household in the upper income group

7- Percentage of household in the upper income group

The travel function is a modified gamma function.

EMPAL is also is a singly-constrained model with lagged employment using an impedance cost matrix for projecting the location of new employment.

According to the author of the model, it has been applied in Atlanta, Chicago, Dallas, Houston, Los Angeles, Sacramento, Boston, Detroit, Kansas City, Phoenix, San Antonio, Seattle, and Orlando.

MEPLAN is another Lowry-derivative model which uses economic base theory in an input-output model framework with price function. An input-output model is applied to represent flows between activities in the form of demand for space. The coefficients of the input-output model are used to calculate prices in an elastic form to represent land allocation within zones. Random utility is used to represent an explicit spatial system where households and firms decide where to live and locate in a utility maximization or a cost minimization framework within specified constraints. This allows market land prices to be considered in the model explicitly. On the same basis, the price of transport might be formulated in terms of time penalties representing congestion.

According to the author of the model, it has been applied in Cambridge and Stevenage, U.K.; Santiago, Chile: Sao Paulo, Brazil; Tehran, Iran; Bilbao, Spain; Helsinki, Finland; Tokyo, Japan.

METROSIM takes an economic approach to modeling housing and land-use location. The model embodies the discrete choice method with economically-specified behavior and a market clearing mechanism. The model is formulated in three market equilibria: 1) labor market equilibrium and job assignment, 2) housing market equilibrium and 3) commercial space equilibrium. The model iterates between these markets and the transportation system for equilibrium of land-use and transportation flows. This model has evolved from applications in Chicago consisting of residential location-housing and mode choice sub-models. In the New York Region's implementation of the model, non-work travel choices and commercial real estate markets were added.

According to the author of the model, it has been applied in Chicago (CATLAS), New York (NYSIM), Chicago, Houston, Pittsburgh and San Diego (CPHMM) and New York (for NYMTC)

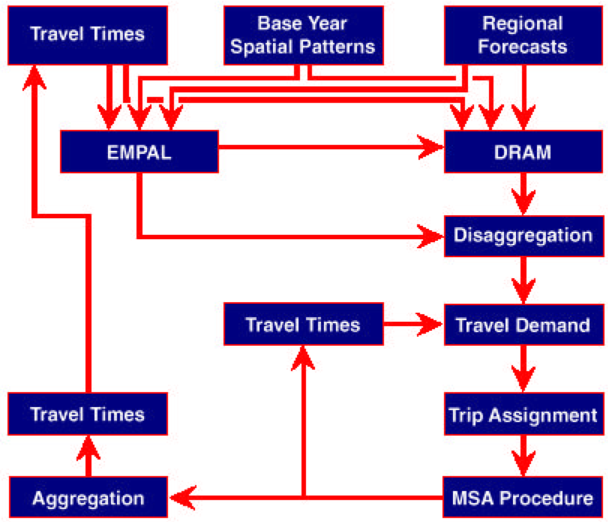
In terms of experiences of other MPOs with land-use models, a telephone interview was conducted with five MPOs using the DRAM-EMPAL model. These MPOs were:

1. Atlanta Regional Commission
2. Northeast Illinois Planning Commission (Chicago)
3. North Central Texas Council of Governments (Dallas)
4. Houston-Galveston Area Council of Governments (Houston)
5. Sacramento Area Council of Governments (Sacramento)

Questions were asked about calibration-forecast years, land-use zones and transportation zone systems, transportation software, household and employment categories and means of projecting control totals. Review processes of forecasts made and use of such forecasts were also questioned. The main finding of the telephone interview was that although there is a need for improvement in the DRAM-EMPAL model, the majority of users are satisfied with the model. However there is one MPO which is actively looking for a replacement. The satisfaction comes from the consensus that instead of starting a new model altogether, efforts should be made by the author of the model as well as the user community to enhance the model system. Those MPOs who are happy with the model attribute their success not only to the model system but also to their own efforts, especially in providing a sound employment location data base.

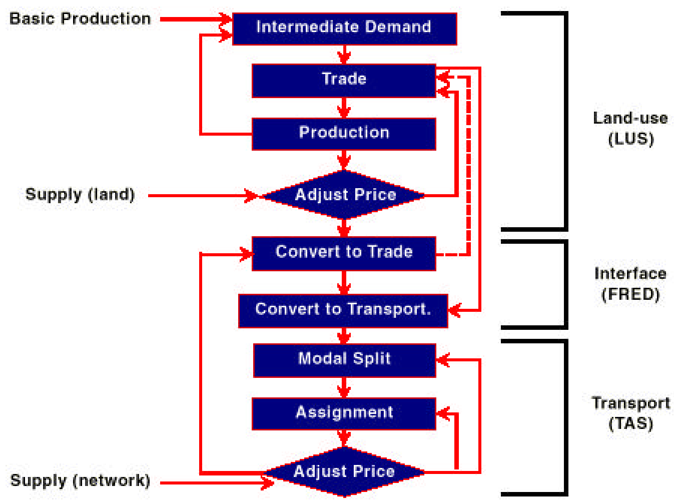
It was essential that the DVRPC model benefit from the experiences of other MPOs with existing operational land-use models. At the same time, improvements to the model system should be possible as the component modules become available. We proposed a two-step selection and implementation phase: short-term and long-term. In the short term we recommended that limited versions of the DRAM- EMPAL, MEPLAN and METROSIM models be acquired for competitive testing in prototype use, policy analysis and impact assessment. For long-term needs, the model system should be modular to allow the insertion of better component modules as they become available.

LINKED MODELS OF LAND USE -TRANSPORTATION: DRAM-EMPAL



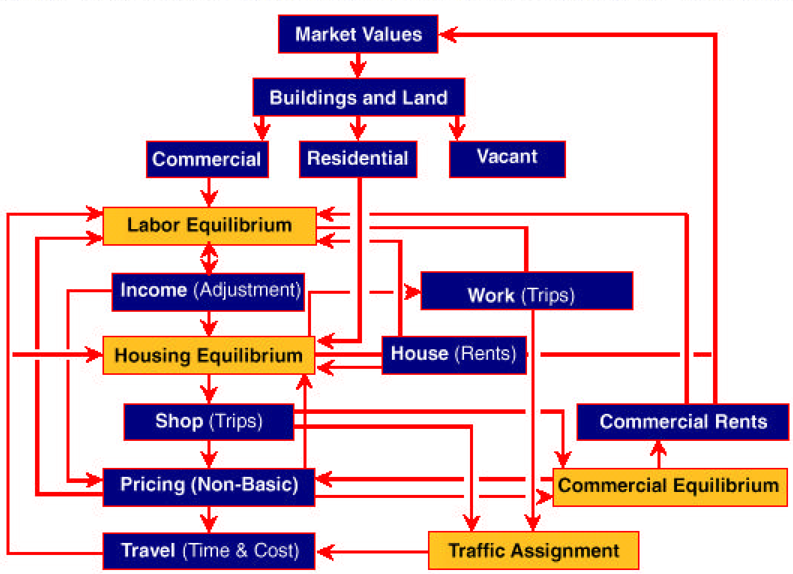
Source: *Equilibrium Condition In Land Use Travel Forecasting, March 1995, S.H. Putnam Associates, Inc.*

MEPLAN MODEL



Source: *"Urban And Regional Studies At The Martine Centre," M. Echenique, 1994*

LINKS AND FEEDBACKS AMONG METROSIM MODULES



Source: *Alex Anas, Model Documentation*

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Socioeconomic Forecasting Model for the Tri-County Regional Planning Commission

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Abstract

The relationship between land use and travel demand forecasting is very strong; at the same time, the methods to represent these relationships in travel demand forecasting models has been cumbersome, complex and difficult to calibrate. The socioeconomic forecasting model was developed for the Tri-County Regional Planning Commission to support the development of the Regional 2015 Transportation Plan. This model created a process to represent the land use and transportation relationship using analytical allocation procedures and incorporating feedback from local jurisdictions. The socioeconomic modeling approach involved developing forecasts at three levels of geographic detail (by county, by Minor Civil Division and by Traffic Analysis Zone) and an interactive projection, review and refinement process.

The process to develop a socioeconomic forecasting model involved the following components: (1) develop base year socioeconomic data, (2) estimate MCD-level forecasts, (3) disaggregate forecasts from MCDs to TAZs, and (4) estimate household size and vehicles per household. The base year population and household data was developed primarily from Census data and the employment data was developed from the Regional Economic Model, Inc. (REMI) and Michigan Employment Securities Commission (MESC) sources. The MCD-level forecasting model relied on trend analysis using historical relationships of population and households, combined with data from local jurisdictions on post-1990 development. The household models (for household size and vehicles per household) were developed using the Census Transportation Planning Package (CTPP) and the Public Use Microdata Sample (PUMS). The household size model estimated household size from population by age group and the vehicles per household model estimated vehicle per household from household income.

The allocation for these socioeconomic forecasts from MCDs to TAZs is perhaps the most unique aspect of the forecasting model. The allocation model is based on local input where this was available, and a combination for accessibility and potential development where local input was not available. Accessibility was calculated as a function of existing population and employment and travel time along the transportation system. Potential development was calculated from the amount of develop able land by zoning classification. The combination for accessibility and potential development was defined as an allocation factor that could be applied to each TAZ. Allocated land uses were carried forward to the next period and incorporated into forecast allocation factors.

The process to develop a socioeconomic forecasting model resulted in several lessons learned about what worked and what didn’t work. The allocation of socioeconomic forecasts from Regional controls to traffic analysis zones can incorporate both local knowledge, accessibility and develop able land. Ideally, local knowledge would account for most of the near-term forecasts and the analytical procedures would be used for longer-term forecasts. The reliability for the base year data is of paramount importance to the reliability of the forecasts and should be accorded adequate resources to improve the process. Specifically, the employment data was troublesome and may be improved by conducting an employment survey. Finally, the process could be improved by developing and maintaining a GIS monitoring program for land use.

Socioeconomic data is a critical input to transportation planning and travel demand forecasting. Accurate estimates of existing population, incomes, employment and other socioeconomic characteristics are necessary for meaningful calibration of a travel demand forecasting model. Technically sound projections of these same data are essential inputs to applications of the travel models to assess future transportation needs and deficiencies. The Lansing Area Travel Demand Model Calibration project, developed for the Tri-County Regional Planning Commission (TCRPC) in Lansing, Michigan, addressed the need for good socioeconomic data. This project developed procedures to forecast the small area distribution of economic and demographic variables required for the TCRPC travel demand model to support Long Range Transportation Plan development.

To balance land use and transportation needs, there is emphasis on managing demand and improving efficiency rather than increasing system supply; on promoting land use patterns which are more conducive to public transportation, and on encouraging more travel by non-motorized modes. The work described here incorporates the interrelation of land use and transportation system characteristics in a simple yet effective way that avoids the problems of more complex land use allocation models.

Alternative Approaches

Many approaches are used to forecast land use and socio-economic variables, and most methods use a “top down” process. Control totals and other exogenous inputs are established at an aggregate level (region, state, city, etc.), and the land use or socioeconomic model is used to allocate activities among smaller areas. Hence, land use forecasting models are often also referred to as activity allocation models.

The range of approaches can be broadly summarized into three categories:

- Models based on formal location theory,
- Analytical allocation procedures following no formal theory, and
- Judgmental or consensus-type procedures.

All three commonly used procedures can produce reasonable results. Location theory models explicitly include transport system costs as a fundamental factor in location choice, while other procedures consider transport factors in a more generalized or subjective manner. The current focus on transportation-system-sensitive land use forecasting, heavily influenced by ISTEA and CAAA, emphasizes location-based models, but this approach is considerably more complex than the other two and still requires many simplifying assumptions. Typically, such models focus on the potential effects of severe congestion on activity distribution but this is important only in the largest of urban areas. They do not capture important factors such as quality of schools, crime rates, and life-styles. The advent of two-worker households has greatly complicated the location decision process making it even more difficult to model. Further, formal models often are applied at an intermediate geographic level larger than traffic analysis zones (TAZs), requiring other disaggregation procedures to produce the final TAZ-level results.

There are many analytical allocation procedures for disaggregating land use activity measures or socioeconomic variables from one geographic level (e.g., minor civil division or MCD) to a more detailed level (e.g., TAZs). These procedures may employ a variety of factors, singly or in combination, such as: existing levels of activity, historical growth rates, knowledge of proposed developments, available developable land, zoning, and proximity to existing development. Often, sophisticated location theory models are used to produce results for subareas of a region and further disaggregation to TAZs is based on factors such as those above.

Largely intuitive or judgmental procedures are also popular. The most common of these is referred to as the Delphi method, which has seen widespread application. In this approach, a panel of relevant experts is used to allocate regional totals to smaller subareas. The process often involves analysis of future land use scenarios and related activity allocations as well as the disaggregation of base year data to TAZs. This procedure can be relatively informal or highly structured with specific forms, procedural steps, scoring schemes, and levels of interaction and reconsideration. Factors described above may also be used in the Delphi approach.

The Tri-County Approach

The relatively low pressures for development and low levels of congestion in the Tri-County region indicated that a sophisticated location theory approach was not appropriate for the Tri-County transportation project. The selected approach is, in effect, a combination of the analytical and judgmental procedures. It provides an automated process incorporating input from local jurisdictions and feedback from TCRPC staff and committees.

The TCRPC region expects only modest growth in population and employment over the next 20 years. The predicted 1990-2020 growth indicates less than a ten percent increase in population for the region and less than twenty percent increase in employment. These modest growth levels mean that current land use patterns will dominate the forecasts of travel demand. Thus, estimates of base year socioeconomic variables are relatively more importance compared to the forecast change in socioeconomic characteristics. Thus, the major focus of the effort was on preparing accurate 1990 base year data at the TAZ level. Base year estimates are critical to the calibration of the travel demand model and as a foundation for socioeconomic forecasts at TAZ level.

Base Year Socioeconomic Data

The base year socioeconomic data variables were selected based on the input requirements for the travel demand model. They were: total population, total households, average household size, average vehicles available per household, and retail and non-retail employment.

TCRPC’s travel demand forecasting model includes a process to cross-classify households by household size and number of vehicles available. This socioeconomic model was therefore developed to estimate relationships for estimating households and vehicle ownership, since the available county and MCD-level forecasts do not provide these data. Table 1 summarizes the data sources used in preparing the socioeconomic estimates presented herein. These included the 1990 Census of Population, the Census Transportation Planning Package (CTPP), the Michigan Employment Securities Commission (MESC) and the Public Use Microdata Sample (PUMS).

Estimates of 1990 population, households, mean household income, and number of vehicles were developed from the 1990 Census of Population and from the 1990 Census Transportation Planning Package (CTPP) using an aggregation of block level census data to Tri-County TAZs. Mean household income and vehicles available from CTPP data at CTPP TAZ level which in most cases correspond with the Tri-County TAZs. The reliability of the Census data and its compatibility with the Tri-County TAZ system produces highly reliable results.

Table 1: Socioeconomic data resources

Data source	Variables provided	Geographic level
Census of Population	Population By Age & Sex Group Quarters Population Households Housing Units by Type HH & Per Capita Income	STF1A: by block, STF3A: by block group
CTPP - Area of Workplace	Workers By Occupation, Industry, Class	655-TAZ System (preliminary version of current 704-TAZ System)
MESC	Employment by individual employer, including Address, Number of Employees, SIC Code	465-TAZ System, 704-TAZ System
PUMS	Population & Households cross-tabulated by one or more variables such as: Household Size, Household Income, #Workers, #Vehicles	Groups of jurisdictions with combined population of 100,000 or more persons
Individual Major/Special Employers	Employment by Type for General Motors Corporation, Michigan State University, local and state government, schools	704-TAZ system

Consolidated employment estimates were developed from MESC and CTPP estimates and incorporated additional refinements from local review. CTPP data, which is inclusive of all employees was used as control totals for most TAZs, while MESC is more accurate on a local level and was used wherever data is available.

Historically, MESC data has been the primary source of employment data by TAZ. Although it is a valuable source, the current files have significant problems with accurate address matching especially where the MESC report is filed at a centralized accounting location rather than actual work place. Also, MESC files only include “covered” employees which excludes most government workers and self-employed persons. It is, however, an important secondary source of employment estimates and the only source available for data on employment by employer (by SIC). A consolidated employment estimate was produced by using the MESC data as the basis for geographic distribution where CTPP was weak, but normalizing to CTPP values at the smallest geographic level for which they were available.

Socioeconomic Forecasting Process

Variety data resources were used in the development of TAZ-level socioeconomic projections:

- 1990 TAZ-level model input data
- 1990 Census data (PUMS and CTPP)
- County level REMI forecasts produced by the University of Michigan
- Population forecasts at MCD-level developed by TCRPC staff and historical data
- Historic employment data from MESC at MCD level for 1965, 1974, 1982, 1990
- The TCRPC inventory of prime industrial sites
- Area of developable land by TAZ based on physical and environmental constraints

The CTPP and PUMS data were used for the household classification models and related forecasting relationships. Data on household income and vehicles from the CTPP was used to model vehicles per household from forecasts of household income produced by the REMI model.

PUMS data provides the most detailed Census information on population, household, and labor force characteristics. It is a sample of the actual Census "long form" responses except residence and workplace locations are coded only to areas of 100,000 or more persons. These areas are termed PUMAs for Public Use Microdata Areas; the Tri-County Region contains three PUMAs. Thus, PUMS provides a valuable source for detailed cross-classifications such as population by age versus household size. In order to provide TAZ-level forecasts of household size tied to the REMI forecasts of population by age distributions, household cross classification relationships were developed from PUMS data to estimate 1990 household size by TAZ.

The University of Michigan produced a set of long-range forecasts of employment, income, and population for all eighty-three Michigan counties using the Regional Economic Model, Inc. (REMI) forecasting models. Population forecasts included a breakdown by age group and gender. Employment forecasts were provided by fourteen industrial divisions. These forecasts, generated for the 1995-2020 period by 5-year increment, are used as county-level control totals. The remaining sources are used to develop forecast data at the TAZ level.

The lack of reliable, consistent historical estimates of socioeconomic variables at TAZ level led to the adoption of a two-stage forecasting process. The first stage in the process is to forecast MCD-level population and employment based on a combination of historical MCD-level estimates and county-level population and employment forecasts. The second stage is to allocate the MCD-level forecasts to TAZ level. MCD-level population forecasts developed by TCRPC staff and MCD-level employment projections based on historical trends from MESC were used as controls for the TAZ-level allocations. This approach made the best use of available data and also provided forecasts that are more easily reviewed by local jurisdictions.

In general, historical trends in building permits and other socioeconomic characteristics provide a basis for developing relative growth rates throughout the region. Existing development patterns, plus recent trends in growth, can be among the strongest indicators of future growth patterns especially where growth rates are modest. While some developments are not well reflected by any of these factors, such developments will be hard to predict by any means unless they are already in the development pipeline. The socioeconomic estimates developed for 1990 provide a strong foundation for socioeconomic forecasts since overall levels of change are indeed modest.

Beyond existing development and current growth patterns, the next most important factor was the potential for new development. Two important indicators are the availability of developable vacant land and proximity, or accessibility, to existing or future activity centers. Usually, there is far more land available for new development than can actually be absorbed by the market within the forecast horizon. Knowing the amount of developable land in each TAZ provides at least a crude check on the reasonableness of growth allocations. For example, a population allocation to a TAZ that yields residential densities well above existing levels is clearly suspect.

Additional data from local jurisdictions was used to enhance the MCD-to-TAZ allocation stage of the forecasting process. This data consisted of:

- Development that has occurred since 1990, by TAZ

- Pipeline developments, by TAZ
- Local policies and programs related to development potential

Where available, input from local jurisdictions on post-1990 development provided a sound basis for TAZ-level allocation of the MCD-level projections of population and employment. With several notable exceptions, relatively little input was available beyond year 2000. However, the data from local jurisdictions yielded population and employment growth that were much higher than the independently-derived MCD-level projections. TCRPC staff reviewed and in several cases modified the MCD-level forecasts of population.

Overview

Socioeconomic forecasts are produced at three geographic levels: County, Minor Civil Division (MCD) and TAZ. This approach takes advantage of MCD forecasts already available, ensures greater statistical reliability, and provides forecasts that can be more readily evaluated by local jurisdictions. Figure 1 shows the major steps in the socioeconomic forecasting process. The boxes at the top indicate the primary inputs to the socioeconomic forecasting process.

The first major step indicated is to develop MCD level forecasts of population and employment by 5-year interval. These forecasts are based on trend relationships from historical data and are described below under the heading *MCD Forecasts*. The second step is to disaggregate MCD population and employment to TAZs by 5-year increments. This is the most complicated step in the process and is described below under the heading *MCD to TAZ Disaggregation*.

Step three is to develop county-level household size and income forecasts by 5-year interval to reflect changes in these characteristics over time. No local forecasts are available for these variables. Although the REMI forecasts do not include these variables, they do include data from which these variables can be derived. Relationships were developed from a combination of 1990 CTPP and PUMS data for this purpose. These relationships are represented in Figure 1 by the box labeled *Household Models* and are described below. The forecasts for these variables are independent of the MCD forecasts at this point in the process.

The fourth step indicated in Figure 1 is to forecast changes in household characteristics by 5-year interval. County-level trends in household size and income developed in step three are applied to corresponding TAZ-level variables to produce future estimates for each forecast year. The effect of income growth on vehicle ownership is also reflected in this step. A key assumption is that the household size, household income, and vehicles per household *averages* estimated for each TAZ in 1990 will not change in a *relative* sense. In other words, the value of each variable will change in response to county trends but the relationship of each TAZ to the county average and the pattern of variation across TAZs within each county will remain relatively constant.

There is no practical way to predict how household size, income and vehicles per household will change for each individual TAZ over time. But, there is now considerable variation in these variables within the region, and they have a significant influence on travel demand levels. In general, these patterns will change only slowly. For example, today's high income areas will tend to remain high income areas in the future. At the same time, it is important to reflect the aggregate change in these variables indicated by past trends and forecasts of the future. The approach retains observed variations by TAZ but increments these to reflect forecast changes at the county level. If

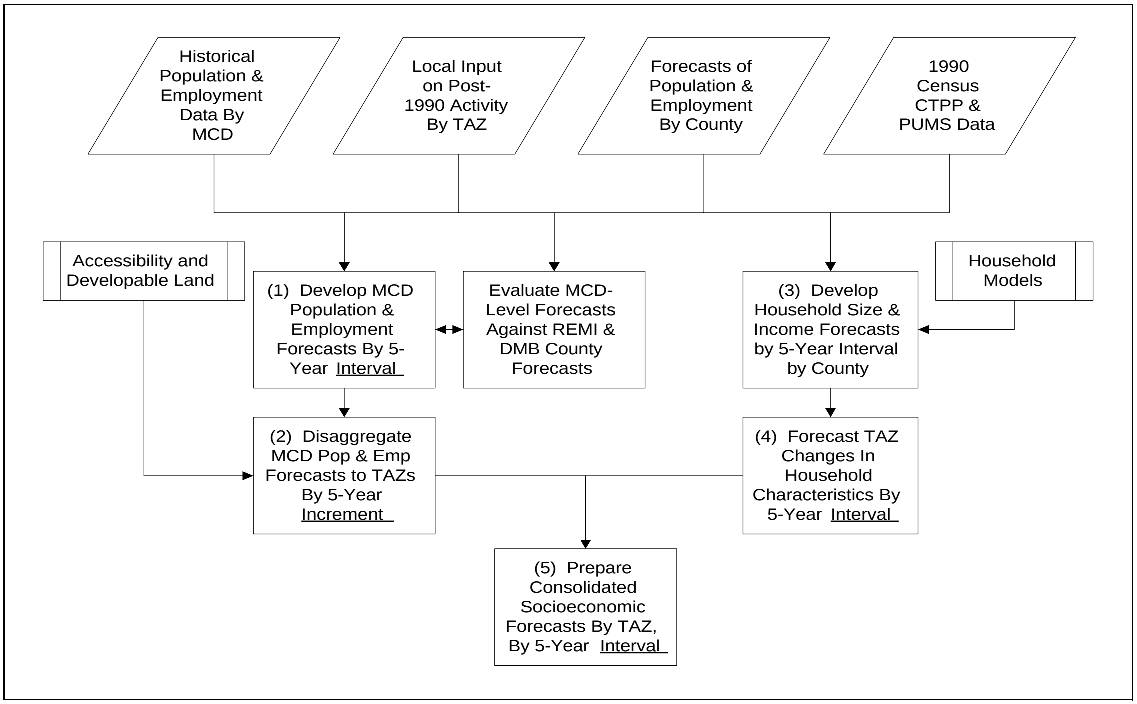

Figure 1: Overview of socioeconomic forecasting process

there is a reasonable basis to estimate changes from base year characteristics, as a result of major new development or redevelopment for example, then such changes could be incorporated in the last step of the process.

The final step is to consolidate socioeconomic forecasts by TAZ for 5-year intervals. The results from Steps (2) and (4) in Figure 1 are combined and any problems, exceptions, or inconsistencies reconciled. The number of households for each TAZ is estimated from the population and the household size forecast independently for each TAZ (Population divided by household size equals households).

The aggregation of TAZ-level households to county level will yield a different total than one produced by dividing county population by the average household size. This is due to the diversity of TAZ household size within each county and the uneven allocation of population among TAZs. For example, if population is allocated primarily to TAZs which have a higher than average household size, then summation of the TAZ household estimates will yield a lower number of households than would be estimated based on county values.

MCD Forecasts

MCD-level forecasts an important part of the overall process because they are a logical step between county-level forecasts and TAZ-level forecasts. The basic steps in the MCD-level forecasting process are:

- *Convert local input to population and employment equivalents*. Population estimates are based on local estimates of housing units multiplied by the TAZ household size. Employment estimates are based on average conversion factors between floor area or acres by type of development from the ITE Trip Generation Manual.

- *Develop trend relationships for MCD population and employment*. Nonlinear regression analysis was used to develop trend relationships using data for 1965, 1970, 1974, 1980, and 1990. The variations in employment data made it necessary to group MCDs into five groups with similar growth patterns.
- *Apply trend relationships to MCDs to obtain forecast population and employment by five-year interval*. Employment trends are expressed as the percent change from 1990 for each five-year interval for each of the five MCD groups. The same percent change was assumed for all MCDs in each group. These relationships derived from historical data for the five MCD groups were used as defaults. Local input were substituted for the default values where they were available.
- *Adjust MCD forecasts to county control totals as necessary*.

MCD-to-TAZ Disaggregation

The TAZ allocations are controlled to the MCD forecasts in a way that makes maximum use of the local input at TAZ level, and reflects the relative attractiveness and development capacity of competing TAZs in a rational way. The steps in the MCD-TAZ disaggregation process are:

- *Step 1: Develop accessibility factors*. Accessibility factors represent the tendency for new development to occur near existing activities and where the transportation system is (or will be) adequate. These factors are calculated as functions of existing population and employment, and measures of travel time. A zone-to-zone travel time matrix and the Gamma function parameters from the HBW trip distribution model were used to derive a friction factor matrix. The friction factors were multiplied by the employment of the destination zone and totaled by the origin zone to represent the origin zone's aggregate accessibility to employment. Likewise, the origin zone population * f-factor values were summed by the destination zone to represent the destination zone's aggregate accessibility to population. Finally, the resulting accessibility measures were divided by the maximum accessibility to yield accessibility factors that range from zero to one.
- *Step 2: Estimate potential development*. The maximum potential population and employment growth in each TAZ was calculated from available developable land by zoning category using average rates of development per acre. These rates, estimated from the ITE *Trip Generation Manual*, *5th Edition*, are 10.5 population/acre; 20 retail employees/acre and 37 non-retail employees/acre.
- *Step 3: Calculate allocation factors*. TAZ allocation factors are calculated by multiplying the accessibility factors and potential development factors to produce a measure of the probability that development will occur in a particular TAZ.
- *Step 4: Compare local input data to MCD forecasts*. The population and employment changes indicated by the local input do not necessarily agree with the incremental changes produced by the MCD forecasts, even though the MCD forecasts have been influenced by the local data as indicated earlier. A key feature of the MCD-to-TAZ disaggregation process is that it deals explicitly and logically with any differences between the two. If the MCD forecast shows a greater change than the local input for a given 5-year period, then the difference is allocated to

TAZs based on measures of development potential derived independently from the local input (Step 5a). If the MCD forecast changes is lower than local data, then the difference is carried over to the next 5-year period (Step 5b).

- *Step 5a: Use TAZ allocation factors to normalize MCD forecasts minus local input data*. The allocation factors are used to allocate any growth forecast by MCD that is not accounted for by local input.
- *Step 5b: Normalize local input data to MCD estimates for current forecast interval; carried over residual local input to subsequent period*. If the local input data for a 5-year interval exceeds the MCD forecasts for that 5-year forecast year, the local input data is still assumed to occur but may take longer than the 5-year interval and will be shifted to the next 5-year interval. In this manner, all local input data is incorporated into the forecasts by TAZ, but the forecast years may be extended if the local data exceeds the MCD forecasts.
- *Step 6: Reduce potential development for subsequent periods by the amount of growth allocated to the current period*. Allocation factors for subsequent years are adjusted to reflect areas where growth has been forecast to occur in earlier periods.
- *Step 7: Iterate for each 5-year forecast period*. These steps are repeated for each 5-year forecast interval until the disaggregation process has completed all forecast years.

Household Models

Forecasts of households, average household size, and average vehicles per household are not available even at county level. Therefore, basic models were developed estimate these variables.

The household models are used to forecast the *change* in corresponding characteristics by TAZ. The models are applied at the county level to estimate *synthetic* values for 1990 and for each forecast year; these values are then used to calculate a ratio or increment of change for each variable for each forecast year. These ratios are then applied to *actual* 1990 values for each TAZ to get the estimated TAZ values for each forecast year. This process retains the pattern of variation throughout the region but adjusts it to reflect trends indicated by county-level forecasts.

Average Household Size

Fortunately, household size is closely related to population by age and the REMI forecasts provide population by age group. A simple model was developed to relate household size to population by age group. As the distribution of population by age group shifts, corresponding changes are reflected in household size. The following steps describe the process:

- *Step 1*: PUMS data is used to cross classify household population by age group versus household size.
- *Step 2*: In order to calculate an average household size by age group, the household population is divided by the household size argument in the first column to get households. Total household population is divided by the total households in each age group to get the average household size.
- *Step 3*: The forecast population for each age group is then divided by the corresponding average household size to obtain estimated households.

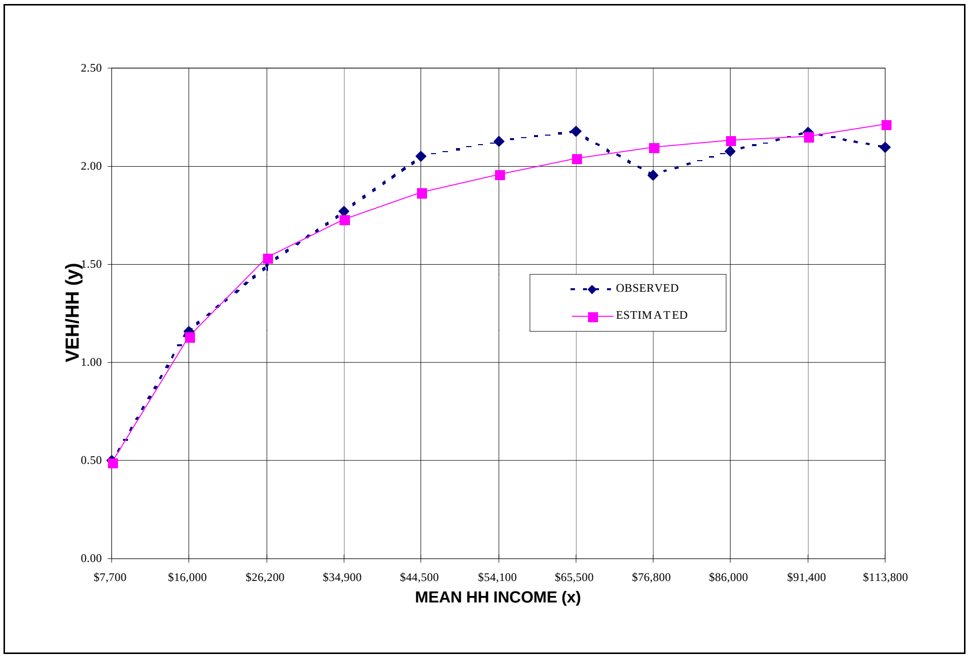

Figure 2: Vehicles per household as a function of household income

- *Step 4*: The households estimated in this way for each forecast year, divided by the corresponding estimate for 1990 yields a *ratio of change* for each county.
- *Step 5*: This *ratio of change* is applied to the actual 1990 average household size for each TAZ to yield the forecast household size.

Average Vehicles per Household

The forecasts of vehicles per household are derived from a relationship of vehicles available as a function of projected household income. The REMI forecasts include income but not vehicles; however, the two are very closely related as indicated in Figure 2 which shows the relationship based on 1990 data. However, that it is not a straight-line relationship. As average household income increases, the average vehicles per household also rises, but at a declining rate. The decline is related to the saturation level of vehicle ownership, about one vehicle per legal driver.

Forecasts of household income are derived from a combination of base year household income, forecasts of personal income from REMI, and forecasts of household size discussed above. Estimates of 1990 household income at both TAZ and county level are based on statewide CTPP data. Forecasts of household income at county level are based on the following relationship:

$$HHINC_y = (PER\_INC_y/PER\_INC90) * (HHSIZ_y/HHSIZ90) * HHINC90$$

where:

HHINC = Average household income for forecast year y / 1990
PER_INC = REMI average personal income for forecast year y / 1990
HHSIZ = Average household size for forecast year y / 1990

Ongoing Model Improvements

TCRPC and KJS are currently working to improve the reliability of the socioeconomic forecasts described in this paper. The current focus is on improving the base year estimates. Data on existing development is critical to the accuracy of the socioeconomic forecasts; and data problems (primarily in base year employment estimates) are the greatest source of inaccuracies by TAZ. The efforts underway to improve the base year data include:

- Improving the completeness and accuracy of the MESC data at the employer level, and
- Correction of geocoding errors affecting the TAZ assignment of specific employers.

The MESC data were compared with data from Dun and Bradstreet, an independent source of disaggregate employment estimates. Use of *Digital Yellow Pages* file helped to determine the existence of a business. Inconsistencies between these data sources are currently being reviewed to assess ways that missing and/or inaccurate employment information can be corrected.

TCRPC staff is also working on a comparison of TIGER and Caliper address files to improve the accuracy of the street base used for address matching purposes. The improved geocoding and address matching process will help ensure that the employers in the MESC data are allocated to the correct TAZs.

The U.S.-Canadian Trade Flow Analysis Project: Summary of Work, Findings, and Recommendations

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Abstract

The United States and Canada have for many years had the largest bilateral trading relationship in the world. In 1994, that relationship resulted in $246 billion in total merchandise trade, up from $189 billion in 1992. That total trade is expected to grow by at least 15 percent per year through 2003, according to the U.S. Department of Transportation's (U.S.DOT) 1993 ISTEA Section 6015 study of North American transportation flows. By comparison, total U.S.-Mexico trade totaled $100 billion in 1994, and is expected to decline somewhat due to recent economic problems in Mexico. That rapidly growing trade has put enormous pressure on infrastructure on both sides of the border. Obviously, there is increasing strain at the border crossings themselves, both structurally and institutionally. But there is also a growing urgency to deal with investment needs in transportation corridors leading to the border. Unfortunately, there has been insufficient information with which to make rational decision about these investments — both from a political as well as U.S. perspective.

The U.S.-Canadian Trade Flow Analysis Project was designed to help fill the critical data gaps for investment decisions on a regional basis. The study has included several elements:

- Analysis and presentation of existing data on trade and transportation flow across the eastern border, extending form Maine to Michigan. Gaps in existing data were identified as well as strategies for their acquisition.
- Forecast of future trade and traffic were made using econometrics time series models and forecasts of import-export trade developed by others.
- A review of each major crossing was undertaken, which were designed to update the information in the Section 6015 Study. Critical deficiencies were identified.
- Several criteria were used to identify U.S.-Canadian transportation corridors. Specific recommendations were made for specific corridors. "Missing links" in the national transportation system were identifies, as well as the economic impact of their provision. For example, a direct linkage between Buffalo and the New York-Philadelphia area was identified as one priority corridor.

This presentation will include an overview of the goals and objectives of the project, the significant data sources and their limitations, principal findings and conclusions, and recommendations for action by federal, state and regional agencies. Other findings, such as the utility of an open border between two countries, will be discussed as well.

Guidelines for Multimodal Corridor Capacity Analysis

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Paul O. Roberts, Transmode Consultants, Inc.

Abstract

Transportation planners and analysts are concerned that sufficient capacity may not exist to handle the projected traffic growth in many corridors throughout the United States. There is a pressing need to address capacity problems not only on highways but on other modes such as rail, waterway and air. Passenger and freight movements on many of these corridors are expected to continue to increase in proportion to the demands for goods, services and mobility in both rural and urban areas.

In the past, growth in highway traffic has been handled by constructing new roadways or by expanding existing ones. Transportation agencies are now more frequently facing situations, particularly in urban areas, where it is impractical or impossible to increase highway capacity, because of physical barriers, environmental impacts and regulations, community opposition, or extraordinary cost.

Most transportation capacity analysis methods, e.g., the Highway capacity Manual, tend to pertain to specific modes rater than concern multimodal corridor analysis. There is a need for a new, more encompassing definition of capacity and corresponding capacity analysis methods. The definition and analytical methods fundamentally should be multimodal/intermodal and have primacy over the capacity of specific modes. Multimodal capacity should be the key constraint in transportation planning and design — the capacity of particular modal facilities and equipment should be a secondary constraint.

This paper identifies some guidelines and procedure for characterizing, analyzing and solving capacity problems in multimodal corridors. The guidelines are the results of the National Cooperative Highway Research Program Project 8-31: *Long-Term Availability of Multimodal Corridor Capacity*. The objectives of this project were to evaluate the scope and severity of current and future capacity problems and constraints on transportation corridors, to recommend strategies to ensure the long-term availability of multimodal corridor capacity, and to identify analytic methods that address both supply and demand side aspects of the multimodal capacity problem.

Practical Methods for Freight Transportation Planning in Metropolitan Areas

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Abstract

COMSIS has been involved in a variety of research and development projects related to freight, including:

- Compiling a freight data inventory;
- Conducting a survey of MPOs on freight studies, including study purposes and methods; and
- Participating in development of the Quick Response Freight Forecast Manual, developing methods for freight similar to those developed by COMSIS for passenger transportation.

Our studies indicate that extensive data related to freight movement are readily available for most metropolitan areas, from a variety of public and private sources. Many of these sources, such as the Bureau of Census' County Business Patterns and Commodity Flow Survey, are not familiar to planners that are more accustomed to working with passenger-focused planning data. However, these data can be used to provide a reasonable profile of freight and other commercial traffic on a corridor-by-corridor basis for most metropolitan areas, and can also supplement a regional transportation model with more accurate freight traffic components. Developing freight and commercial traffic profiles generally involves a combination of some or all of the following:

- Data or businesses that generate or handle freight movements
- Land use patterns
- National/regional commodity flow data
- Truck (and possibly some rail, ship, barge, and air) traffic counts
- Freight traffic generation rates and other model parameters from other areas that have undertaken extensive surveys. The compilation of values and the methodologies for applying such parameters or default values to a local forecast is one of the primary contributions of the Quick Response Freight Manual.

The developed profile will usually include a description of shippers, receivers and freight handling business in the corridor, the nature and amount of commodity flow into, out of and through a corridor, and daily vehicle trips by mode — truck, rail, ship, barge, air, and possibly pipeline.

Many MPOs across the country, of all sizes, are currently engaging in, or have recently completed freight studies. Most have included surveys of one type or another. Many more MPOs may be interested in freight issues, but may be concerned about cost of acquiring data and generally unfamiliar with freight terms and modes of operation. We propose to present an introduction to the broad issues and methodology, plus references as to where to go for further information.

A Priority System for Multimodal and Intermodal Transportation Planning

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and Eric Rothstein, CH2M HILL, Inc.

Abstract

Prioritization is an increasingly important concept for transportation system planning and programming. The resources for capital improvements to state and regional transportation systems are stagnant or declining. AT the same time, population growth, urban development patterns, and travel behaviors are increasing the demands placed on transportation systems. The number and range of interest groups, each with separate sets of transportation objectives, make it increasingly difficult to pinpoint the "public good." ISTEA mandates consideration of multiple modes, but it is difficult to compare the relative benefits of projects across modes. Public trust in the ability of government agencies t make resource allocation decisions can be intense. Given all these factors, planners need to prioritize. They need to make hard choices about which projects to select for funding, and which to scale back, postpone or not fund at all. Formal priority systems can help planners identify and justify the choices that achieve the greatest benefit in this complex environment.

This paper describes an innovative application of formal prioritization principles to intermodal planning. A priority system was constructed as part of the development of Oregon Department of Transportation Intermodal Management System. It is designed to help identify transportation system needs based on quantitative, facility type-specific performance measures; to rank the needs; and to prioritize projects for meeting the needs. In addition, the system provides an opportunity for sensitivity analysis to distinguish which assumptions or uncertainties significantly affect priorities from those that do not. This information can point the way to data collection efforts that are most effective in improving the allocation of investment resources. This work produced a practical and logically defensible system for supporting the ODOT planning process, and generated concepts and models of potential use for other aspects of transportation planning and programming.

The priority system was tested through an application to 25 actual intermodal system needs and proposed projects. For example, the application compared projects to improve truck access to a railway yard, widen a roadway segment, build a railroad overcrossing, and add information kiosks at a passenger terminal. Following the system logic, needs were ranked based on the benefit that would result from eliminating those needs, and projects were ranked based on benefit-to-cost ratio.

Topics addressed in the paper include principles of prioritization, methods of quantifying benefit, models for estimating performance for ten types of intermodal transportation facilities (connector and mainline roadways, bus station, rail passenger stations, air passenger terminals, marine terminals, rail truck facilities, grain, reload facilities, petroleum terminals, truck terminals, and air cargo facilities), ranking methodologies, and software implementation.

Prioritization is an increasingly important concept in transportation system planning. The resources for capital improvements to state and regional transportation systems are stagnant or declining. At the same time, population growth, urban development patterns, and travel behaviors are increasing the demands placed on transportation systems. The number and range of interest groups, each with separate sets of transportation objectives, make it increasingly difficult to pinpoint the "public good." The Intermodal Surface Transportation Efficiency Act (ISTEA) mandates consideration of multiple modes, but it is difficult to compare the relative benefits of projects across modes. Public trust in the ability of government agencies to make effective and efficient use of public funds is at an all-time low, and public scrutiny of resource allocation decisions can be intense. Given all these factors, planners need to prioritize-they need to make hard choices about which projects to scale back, postpone, or not fund at all. Formal priority systems can help planners identify and justify the choices that achieve the greatest benefit in this complex environment.

This paper describes an innovative application of the formal principles of prioritization to intermodal transportation planning. The project-conducted for the Oregon Department of Transportation (ODOT), Metro (Portland's metropolitan planning organization [MPO]), and the Port of Portland-developed a formal priority system known as the Intermodal Transportation System Prioritization Model (ITSPM). ITSPM is designed to help identify critical needs of the intermodal system, rank those needs, and prioritize projects proposed to meet them. It is important to note that the priority system is not intended to make decisions; rather, it provides information for decisionmakers. This work produced a practical and logically defensible system for supporting the ODOT and MPO planning processes. It also generated concepts and models of potential use for other aspects of transportation planning and programming.

Principles of Prioritization

According to prioritization theory, projects should be prioritized based on the ratio of benefits generated to project costs. If proposed projects are independent of one another and can be either funded or not, then the set of projects offering the greatest possible benefit for the available budget will be that which is produced by ranking the projects by their benefit-to-cost ratios and then funding them from the top down until the budget is exhausted. Another basic prioritization principle is that the prioritizing criteria should be derived from objectives. By definition, any incremental improvement in the achievement of an objective is a benefit.

Following this theory, prioritization criteria for ITSPM were derived from statements of the basic objectives for the ODOT intermodal transportation system. Objectives were defined by an advisory panel of transportation managers and experts assembled for the project and were reality-tested through interviews with facility operators and system users. The following objectives were identified:

- Satisfy the demand for transportation services
- Maximize the quality of service to customers
- Maximize safety

Benefit was defined as an incremental improvement in the achievement of one or more of these objectives; priority system logic is directed at quantifying such benefit.

Quantifying Benefit

Performance measures were defined to quantify the degree to which transportation system objectives are achieved. Facility usage, or throughput of people, vehicles, and freight, was defined as the performance measure for quantifying the satisfaction of demand. Thus, projects were assumed to improve the satisfaction of customer demand if they result in increased facility usage, or throughput. Two measures were defined for quality of service. One is user service time. In the

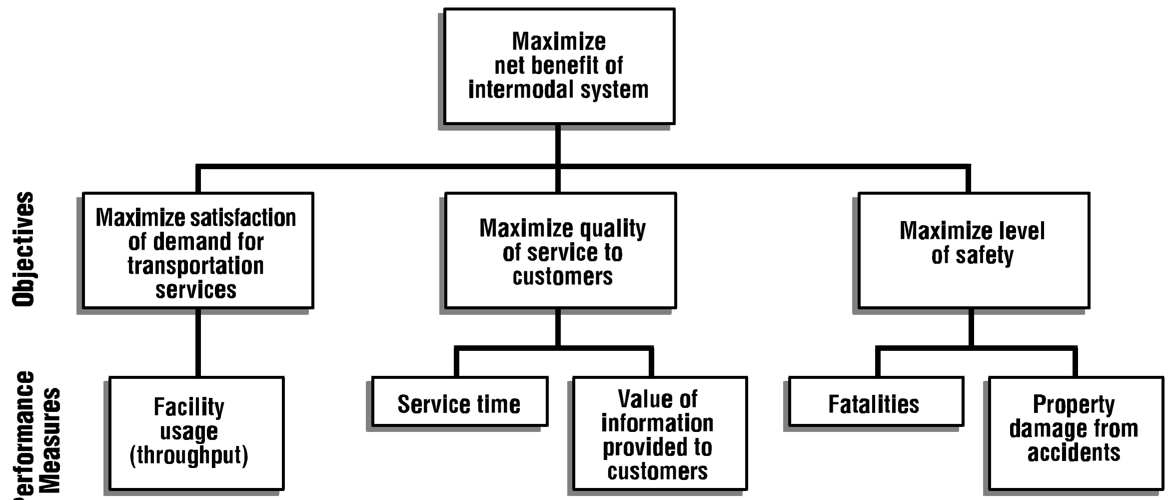

Figure 1. Priority System Objectives and Performance Measures

case of roadways, for example, a project may improve the quality of service if it decreases the traffic delays experienced by motorists. The second performance measure for quality of service is the value of information provided to potential customers. Thus, for example, improved signage to facilities on connector roadways and placement of information kiosks in passenger facilities were assumed to improve service to the extent they provide information useful to customers. The level of safety is measured by fatalities and property damage resulting from accidents. Figure 1 summarizes the relationship between performance measures and objectives.

To permit the comparison of projects that improve different performance measures (e.g., a project that reduces traffic accidents versus a project that reduces customer delays), the measures of performance are converted to equivalent dollar values. Thus, the system allows project benefits to be expressed either in the units of system performance (e.g., a reduction in total customer delays, expressed in minutes) or in dollar values. The conversion is accomplished using a set of value weights (e.g., equivalent dollar value per fatality averted, equivalent dollar value per hour of travel time saved). These weights are input parameters for the system. Although the model contains default weights based on surveys, expert judgments, and willingness-to-pay data, users can alter these parameters to reflect their personal value judgments or the value judgments of their organizations.

Models for Estimating Facility Performance

Models were developed to estimate the performance measures for ten types of intermodal transportation facilities. These facilities include bus stations, rail passenger stations, air passenger terminals, marine terminals, rail truck facilities, grain reload facilities, petroleum terminals, truck terminals, air cargo facilities, and connector and mainline roadways to these facilities. The models consider both current levels of service as well as projected future conditions. For example, all of the models allow for input of growth rates to convert current levels of throughput into estimated future levels. This ability to take into account expected future conditions is unusual; most models limit future throughput to the maximum capacity of the existing facility. As usage rates approach capacities, the models estimate the increased delay times for users.

The models for estimating the value of safety and information are relatively simple. The economic costs of facility accidents are estimated by multiplying the number of accidents by the average dollar loss per accident. The dollar cost per accident includes the average property damage cost plus an equivalent economic cost for injuries and the risk of loss of life. To estimate the value of information from improved signs, for example, a potential user is asked to input a raw estimate of information value based on the usefulness of the information to customer decision-making. This value can be estimated using decision analysis techniques for calculating the value of information. The raw information value is then multiplied by an estimate of the number of users who will receive the information (e.g., the number of people expected to walk past a sign providing instructions) and multiplied by a factor representing the estimated effectiveness of the chosen mode of communication. In some cases, effectiveness is reflected in reduction of service time.

The models for estimating user service times are more complex, but they are based on standard algorithms and straightforward logic. In the case of roadway segments, for example, the model uses peak-hour volumes and assumes that these volumes will occur for 3 hours during a typical weekday. Stoppages (calculated in seconds per vehicle) traditionally associated with volume-to-capacity ratios are used as input to a delay model that also incorporates other factors affecting delay, such as roadway geometrics, barriers (e.g., at grade rail crossings), pavement conditions, and entering driveways. Intersection delay is also calculated using standard algorithms that consider the characteristics of the intersection (e.g., number of lanes, configuration, type of signalization, etc.). The average delay per vehicle is estimated based on the ratio of intersection volume to capacity. For each period, the total delay is the average delay per vehicle times the total number of vehicles entering the intersection. Total intersection or road-segment delay is the sum of the delays over the 20-year planning horizon, taking into account traffic growth projections.

The system allows field data or traffic model outputs to be substituted for estimates provided in the priority system model. In Portland, for example, delay time can be estimated by Metro's traffic model and is likely to be more accurate. However, in many parts of the state no system models are maintained, and even where models exist, many of the local road segments connecting intermodal facilities to the mainlines are not included. Traffic model outputs can be used over time to refine the priority system delay models.

Identifying Needs, Ranking Needs, and Prioritizing Projects

ITSPM uses available data, user-provided inputs, and its performance models to identify and rank needs and to prioritize projects. To aid in the identification of needs, threshold levels of performance are associated with factors represented in the performance models. For example, for accident rates, the threshold is set at 150 percent of statewide average rates at similar facilities. As another example, if throughput at a passenger or freight terminal is approaching the capacity limit for the terminal, a need to increase terminal capacity is identified.

Needs are quantified by computing the improvement in the facility performance measures that would result if the need were eliminated. Thus, for example, the need to reduce delays is quantified by computing the total user time that could be saved if all drivers could drive at the posted speed limit. Or, at a container port where a need for additional capacity is identified, the volume of additional twenty-foot equivalent units (TEUs) that could be handled over the 20-year time horizon by expanding the facility is calculated (see Figure 2). From this volume, the estimated improvements in performance measures can be converted to equivalent dollar benefits using the value weights. ITSPM ranks needs in order of the magnitude of the estimated benefits. The need which, if eliminated, would produce the greatest increase in benefit is ranked first.

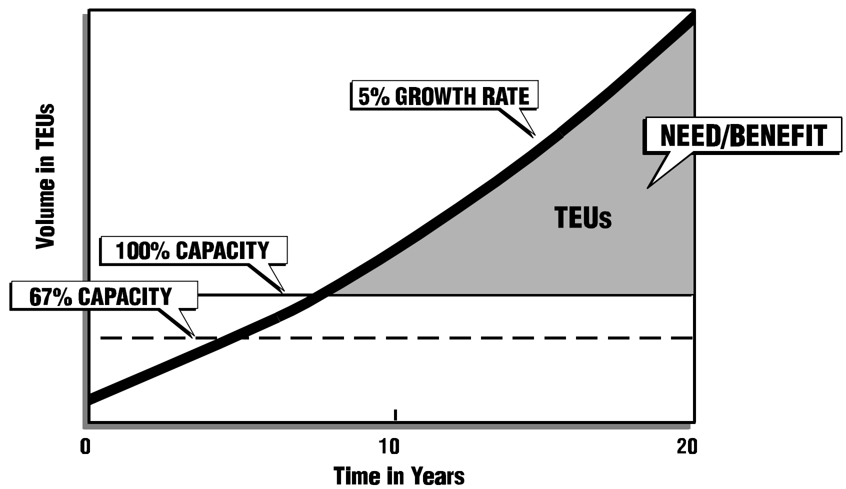

Figure 2. Capacity Need Calculation for a Container Port over a 20-Year Time Horizon

ITSPM ranks projects by estimating the changes in facility performance measures that would result if each project were to be implemented. To evaluate a project, the user specifies the data elements that would be changed as a result of the project (e.g., an addition of a lane to a road segment). The facility models are then used to estimate incremental improvements in performance (e.g., reduced delays), and the value weights are used to convert performance improvements to an equivalent dollar benefit. If a project produces multiple performance improvements, the benefits are summed to obtain the total benefit of the project. That benefit is then compared with estimated project costs, and projects are ranked by their benefit-to-cost ratios.

Note that the ranking of needs requires fewer inputs by users than does the ranking of projects. As indicated above, the system ranks needs by estimating the benefit that would result if each need were eliminated. (i.e., the improvement in the achievement of objectives that would result if a sub-par level of performance could be replaced by a desired or ideal level of performance). Ranking needs is simpler because it does not require inputs describing the characteristics of the project proposed to address the need. However, unlike project ranking, need ranking does not consider the cost-effectiveness or feasibility of eliminating the need.

Software Implementation

A pilot version of ITSPM has been implemented using Microsoft Excel (Version 5.0c). The pilot implementation is a simple spreadsheet model that includes three facility types: lineal roadway segments, intersections, and passenger terminals. The program has four main sheets that perform calculations, plus an “Input” sheet that facilitates data entry and a “Results” sheet that aggregates and summarizes results from the other sheets. The Input sheet requests data to perform the need and benefit calculations-it includes a section for existing facility characteristics and a section for the facility characteristics as they would appear following the execution of a proposed project. The calculation sheets compute the facility performance measures under existing conditions and under the improved conditions resulting from elimination of facility needs and from the implementation of proposed projects. Benefits of candidate project improvements are determined in terms of the differences in performance measures between improved and existing conditions. Annual operations and maintenance (O&M) costs are input data; capital costs are debt-service payments calculated under the assumptions that capital costs will be financed over the forecast period on a levelized payment basis. Annual benefits and costs are calculated using a discount rate. The difference between these values is the net present value of the candidate project. The ratio of the present value of benefit to present value of cost is used to rank candidate projects.

The ITSPM has been incorporated into the ODOT Intermodal Management System (IMS) database. The IMS database and computer program were developed in a user-friendly Windows format that consists of a logical and physical database design and a series of programs to accommodate collection and editing of data. The database also allows updates as well as access and manipulation of the data to support analysis. Users are able to perform queries based on any combination of system attributes, view data on one or multiple IMS elements, calculate performance measures, and produce rankings in user-specified formats.

Sample Application

ITSPM was tested through application to 34 actual transportation system needs and the projects proposed for addressing those needs. For example, the application compared projects to improve truck access to a railway yard, widen a roadway segment, build a railroad overcrossing, and add an information kiosk at a passenger terminal. Input data for the various projects included current facility usage and annual growth rates, times of roadway blockage and facility downtimes, the numbers of lanes and lengths of roadway segments, average roadway speeds and posted speed limits, types of signals at intersections, number of property damage and fatality accidents, information access rates, and estimated project capital costs and ongoing O&M costs. The facility performance models were used to calculate future annual throughput rates, customer services times, information value provided to customers, and fatality and property loss rates. Following the system logic, needs were ranked based on the benefit that would result from eliminating those needs and projects were ranked based on the benefit-to-cost ratios.

The results demonstrate the value of a formal priority system. Given the large number of considerations relevant to assessing the value of proposed projects, it is extremely difficult to evaluate and compare those projects without the aid of formal prioritization logic. Thus, although the resulting ranking was viewed in retrospect to be intuitive, it is unlikely that even experienced planners could have obtained the results without the aid of the system. In general, highly ranked needs tend to be those that (a) significantly detract from the facility's ability to achieve a favorable level of performance and (b) impact a large number of actual or potential facility users. Highly ranked projects tend to be those that (a) are estimated to alleviate substantially one or more highly ranked needs and (b) do so at low to moderate total cost.

In addition to providing an integrated ranking of needs and projects for the whole system, need and project rankings can also be provided by need type (e.g., the facility with the greatest capacity need, or the project that provides the greatest safety benefit), or by facility type (e.g., the marine terminal with the highest aggregate needs of all marine terminals, or the project that provides the highest benefit to air passengers). To respond to geographic equity issues created by metropolitan/rural differences in the sizes and types of facilities, need and project rankings can be prepared for individual regions rather than for the state as a whole.

Conclusions

ITSPM demonstrates the practical value of using formal prioritization logic to aid in transportation system planning. In addition to providing a defensible prioritization of needs and projects, the priority system directly incorporates public values through objectives formulation, allows “apples to apples” comparisons of different types of needs and projects, increases understanding of value trade-offs, provides a mechanism for achieving consensus decisions among diverse stakeholder interests, is auditable and replicable, and fosters efficient use of limited resources.

Another important benefit of the system is its ability to answer “what if” questions. Sensitivity analyses can be conducted wherein importance weights and other value assumptions are varied across a range of values chosen to reflect different opinions. Sensitivity analyses can also be conducted wherein performance measures are varied across their ranges of uncertainty. Those assumptions or uncertainties that significantly affect priorities can be distinguished from those that do not. The identification of critical assumptions points the way to additional analyses and data collection efforts that can most effectively improve the allocation of investment resources.

The cumulative cost/benefit curve provided as an output of this priority system can increase agency credibility by showing the direct linkage between benefits received for particular levels of funding (see Figure 3). The return on investment is much greater on the steeper part of the curve. Showing high multiples of benefits related to cost in this graphic format is often useful for justification of increased allocations.

Other relevant applications for this type of priority system include other ISTEA management systems, as well as project selection for State and Metropolitan Transportation Improvement Programs, Congestion Management Air Quality/enhancement programs, and city/county capital improvement programs.

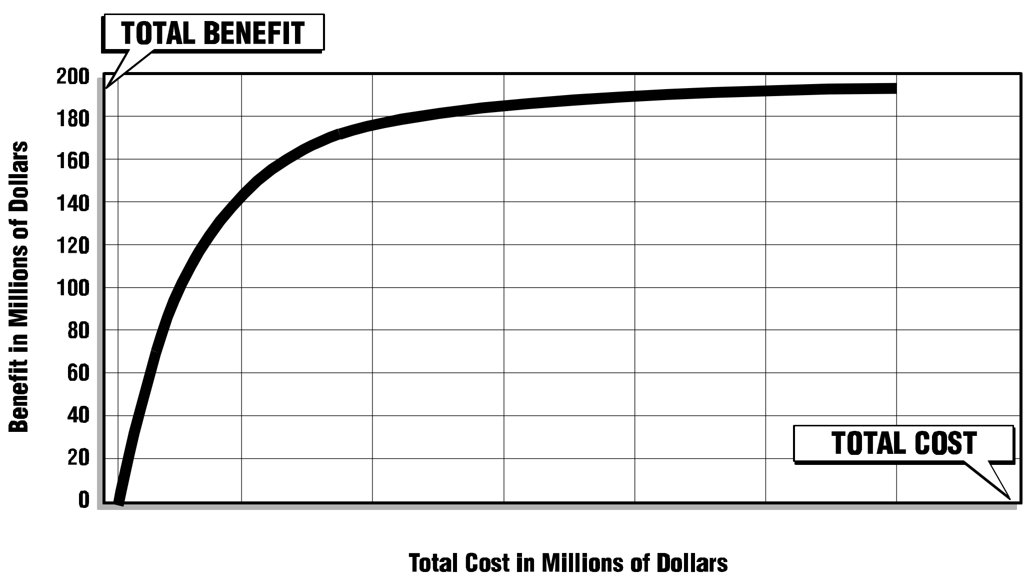

Figure 3. Cumulative Cost/Benefit Curve

Case Studies in Intermodalism: Planning Airport Access

Ronald Ratliff, Brian Reed, Terrel Shaw, and Chip Seymour,
Reynolds, Smith and Hills, Inc.

Abstract

The development of 23 of our nation's 41 largest airport's operations are constrained by landside access congestion. Not only does this congestion constrain airport operations but congestion at these terminals impedes overall system performance by contributing to air pollution. this congestion is also a barrier to economic activities that are dependent on reliable and efficient access to the passenger and freight terminals within the airport. Access needs tot airports are also being influenced by aviation operations that are placing increased demand on surface transportation systems. For example, aircraft seating capacities and load factors have been increasing over the last decade and contribute increased peaking characteristics of landside access demand resulting in a less efficient utilization of landside resources.

This paper will explore the principles of good airport access planning and illustrate through case studies, examples of the applications of these principles. The following topics will be explored:

1 mobility needs of freight and passenger movements,

2 trip segmentation and analysis,

3 system and demand management techniques, and

4 capital investment and financing strategies.

Two airports of unique requirements were selected: Alexander Hamilton Airport (St. Croix, U.S. Virgin Islands) and Richmond, Virginia. The Alexander Hamilton Airport case study will demonstrate a planning approach that involves highway and bus transit access that involves a critical link to marine port facilities. The Richmond case study will demonstrate a comprehensive planning approach to promote freight operations at an airport facing modal integration needs involving highways and rail.

Intermodal Ground Access to Airports: A Planning Guide - A Good Start

Phillip S. Shapiro

Access to airports has been discussed as an expanding transportation problem in the US since the early 1970s.[1] As air travel, urban congestion and environmental concerns have significantly increased over the last quarter century, planning for multimodal access to airports has become an even more important topic. U.S. Department of Transportation (USDOT) guidance for airport access planning has been limited.[2,3] The increasing need to plan for intermodal facilities and increasing airport access problems led to the development of an *Intermodal Ground Access to Airports: A Planning Guide* for the Federal Highway Administration and Federal Aviation Administration, by BMI.

This *Guide* is designed to provide policy guidance, rules of thumb, data, and analytical techniques related to airport access. It has been prepared to help airport operators, local governments, metropolitan planning organizations (MPOs), consultants and others identify the nature of airport access problems, identify alternative solutions and evaluate their effectiveness. It primarily compiles information from other sources, however it does summarize and present this information so that it can be used to systematically analyze airport access problems and alternative solutions.

The *Guide* primarily focuses on providing passengers access to commercial airports from primary origins or destinations. It deals with:

- Off-airport roads, and high occupancy (HOV) facilities up to the airport boundary.
- On-airport roads, parking circulation elements and curb facilities up to the terminal entrance.

Importance of Airport Access

As shown in Figure 1, total annual passenger enplanements in the United States, including commercial, international and commuter passengers, are projected to grow by over 400 million enplanements between 1995 and 2005.[4] This 50 percent growth in total enplanements will generate significant problems for groundside facilities at many U.S. airports. Some components of passenger traffic will grow even faster than the average; enplanements on international flights will grow by over 75 percent and enplanements on regional commuter flights will nearly double during this ten year period.

This growth in demand for air travel will generate increased problems for groundside facilities at commercial airports, particularly airport access facilities. Historically, passengers have predominantly used the private automobile to access airports, and this will probably continue to be the primary mode of access for the foreseeable future. However, as passenger demands increase, multimodal alternatives will become increasingly important to the efficient utilization of access facilities on and around U.S. airports. Enplanements at small and medium hub airports, where a large percentage of regional commuter service is provided, will increase at a faster than average rate. Even these airports, that have had very little multimodal access in the past, will probably need to increase access options provided to passengers using their facilities in the future.

In 1994, nearly 100 operators of small, medium and large hub airports were surveyed by Airport Council International-North America (ACI-NA) regarding the importance of airport access issues affecting their airports.[5] Operators were asked to rate airport access issues on a scale of 1 (no problem) to 5 (significant concern).

Three of the identified areas of concern were:

- Off-airport access roadway congestion,
- On-airport roadway congestion, and
- Curbside Congestion

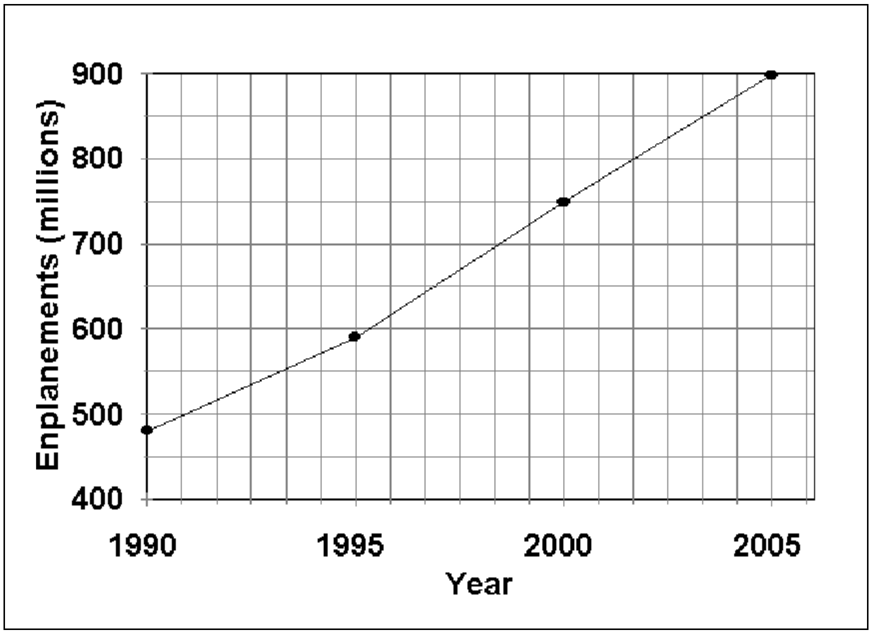

Figure 1: Total scheduled passenger enplanements at US commercial airports

The results of this survey are shown in Table 1. At least a third of all surveyed airports rated all three areas with a 4 or 5. At least 45 percent of large and medium hub operators expressed concern for on- and off- airport roadway congestion. Operators of over 75 percent of these larger airports and nearly 50 percent of small hub operators expressed concern over curbside congestion.

Travelers and operators alike have become increasingly aware that air travel is comprised of a combination of time in the air, time spent at the airport, and the time on the ground spent getting to and from a destination. Nearly 75 percent of airport operators surveyed by ACI-NA indicated that passengers experience more delay on access and circulation roads than they do on the airfield. As access to airports becomes more difficult and time consuming, inadequate access will increasingly limit the growth potential of airport facilities. Some researchers predict that as air travel increases the number of multiple airport hubs will increase.[6] Airports in neighboring metropolitan areas also are competing with each other as demonstrated after the opening of the new Denver Airport and as has been experienced for over a decade in the Baltimore and Washington metropolitan areas. As air travel times from competing airports become more and more comparable, airport access will become more of a determining factor in the airport chosen by travelers.

Clearly, airport operators are concerned about airport access congestion. With the projected increase in enplanements over the next 10 years these concerns will probably increase. The pref-

Table 1: 1994 ACI-NA survey of airport surface access critical issues and concerns

Issue	No problem ◄——			——► Significant concern
	1	2	3	4	5
Off-airport access roadway congestion	17%	25%	21%	15%	21%
On-airport roadway congestion	18%	28%	22%	19%	14%
Curbside congestion	5%	12%	22%	30%	31%

erence by passengers for automobile-based airport access and the increased demands for facilities to accommodate those automobiles will continue to put pressure on access facilities. Airport authorities and government agencies responsible for providing ground transportation access facilities will need to improve the way that automobiles are accommodated at airports, and increase the availability of competitive alternative high occupancy modes that decrease reliance on the private automobile.

It is anticipated that few conventional “new” airports will be constructed in the next decade, particularly in metropolitan areas of the United States. Consequently increases in air and landside activities brought on by such factors as ever increasing air traffic, new airlines, and larger aircraft will mean numerous existing airports will have to undergo expansion. Therefore the airport owner/operator and government agencies responsible for planning and providing transportation facilities will be directly involved in planning for improved access to existing airports and providing new access facilities to the few new airports that are built. These operators, planners and engineers will need guidance on how to better plan for airport access needs. The *Guide* will begin to provide that guidance.

Relationship Between Ground Transportation Characteristics and Originating Passengers

Planners and engineers usually determine airport facility needs based on existing and projected enplanements at an airport. Enplanements at an airport include all passenger trips that begin or end at that airport as well as any transfers from one flight to another. Unlike many other airport facilities, ground transportation access needs are driven primarily by passenger trips that begin or end at the airport.

At some airports such as Washington National and Oakland (CA), where almost 90 percent of all passengers start or end their trips locally, future ground transportation needs can be determined by using projected enplanements. At other airports, such as Atlanta Hartsfield and Chicago O’Hare, originations are less than 50 percent of total enplanements and ground access needs may not be well represented by passenger enplanements. A particular problem for determining ground access needs occurs when enplanements and originations grow at different rates such as was experienced at Baltimore Washington International Airport in the early 1990s.

One of the goals of the *Guide* is to provide planners with rules of thumb that can be used for preliminary assessments of ground access needs based on the experience of similar airports. In order to achieve this goal the *Guide* relates ground transportation characteristics with originating passengers at airports. This paper presents airport access facilities, parking requirements, curbside design, and mode of access characteristics of different size U.S. airports. These characteristics are summarized by the following annual originating passenger levels:

- Less than 500,000,
- 5000,000 to 1 million,
- 1 million to 2.5 million, and
- Over 5 million.

Access Facilities

Airport access can be greatly improved by the construction of new roadways, including “dedi-

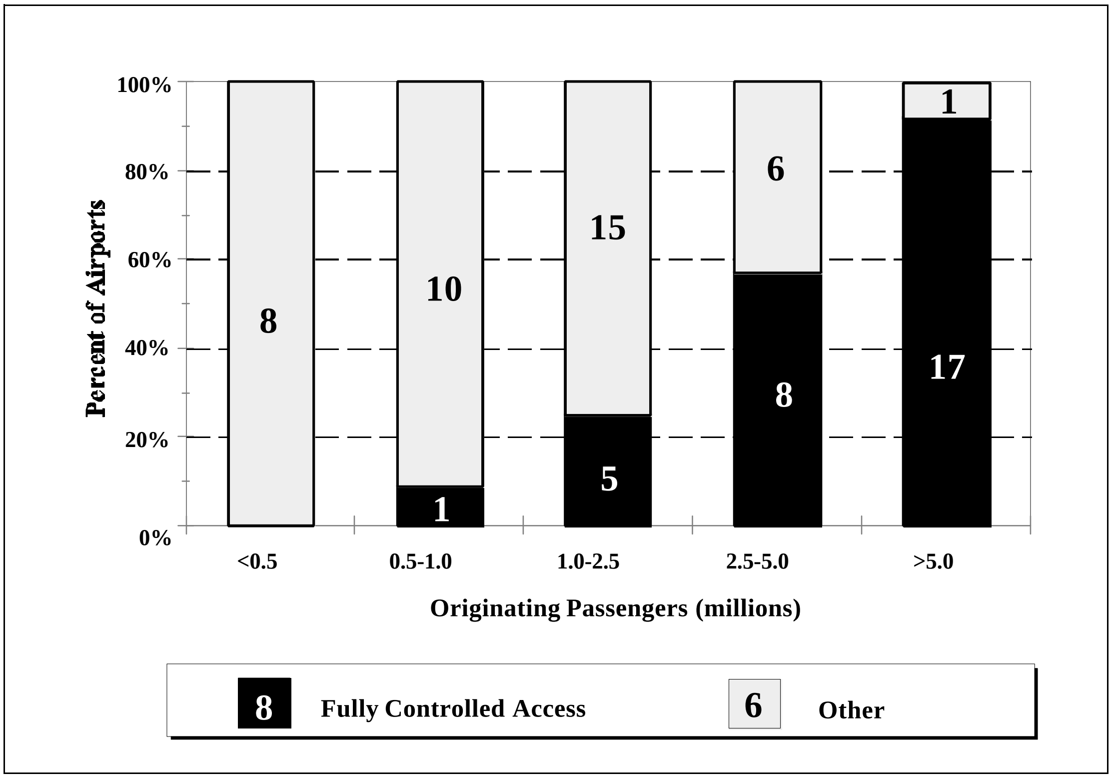

Figure 2: Primary airport roadway access facilities

cated" roadways that lead directly to the airport and spurs from freeways that are constructed in accordance with interstate design standards. Access highways to large airports often have full control of access with no crossings at grade, however most smaller airports with less than 2.5 million originating passengers function without being served by a controlled access facility. Figure 2 illustrates the proportion of different size airports that are directly served by controlled access facilities. As can be seen in this figure, 95 percent of the airports serving more than 2.5 million annual originating passengers are accessed via fully controlled highways. Only 20 percent of the airports with 1 to 2.5 million annual originations are served by fully controlled facilities and only one of the nineteen airports with less than a million originations have controlled access. This analysis shows that airports generally do not need to be served by controlled access facilities until they are seeing more than a million originating passengers, even then it is not critical until they are much larger.

A second analysis was performed to identify when airports begin to need more than one major roadway for access. The results of this analysis, which is displayed in Figure 3, indicates that multiple facilities are not usually needed until an airport is serving more than five million annual originations.

Curbside Configurations

One of the most valuable, highly utilized and congested components of an airport access system is terminal curbside. This area provide the most convenient location for passengers to transfer between an airport terminal building and ground access. It is used by automobiles, buses, taxis,

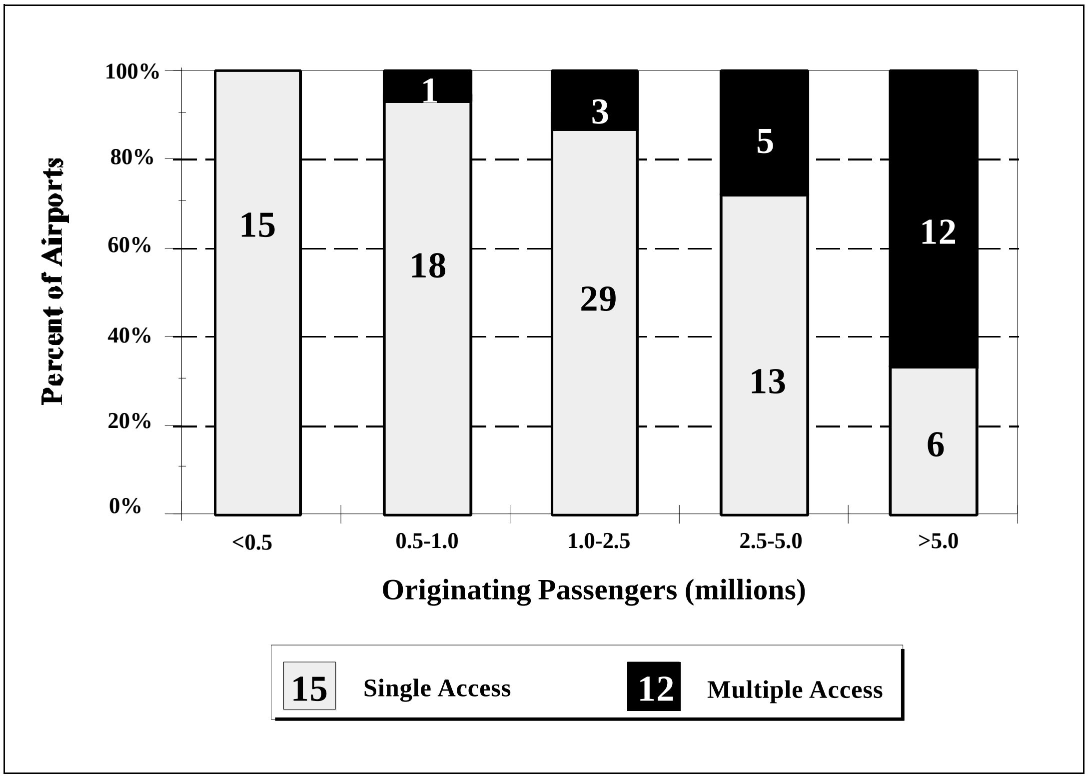

Figure 3: Airports with multiple access facilities

limousines, courtesy vehicles and other rubber-tired modes to pick up and discharge passengers that originate or terminate their air trip at the airport.

Additional curb space can be provided in several ways, some of which are only appropriate when implemented with the construction of a new terminal facility or parking garage or reconstruction of existing facilities. Additional curb space can be provided through:

- *Horizontal Curbside Separation* such as parallel curbsides with a raised center island for passenger pick up or drop off.
- *Vertical Curbside Separation* such as two roadways that serve different airport levels, and
- *Supplemental Curbside Areas* such as facilities adjacent to the terminal buildings in surface parking lots, parking structures, or “ground transportation centers”.

An analysis of the terminal design of over a hundred American airports of different sizes was performed to determine a relationship between curbside configuration and passenger originations. The results of this analysis are shown in Figure 4. This analysis found that most American airports with less than a million originations per year have single level terminals and as originations increase, the proportion of airports with multiple level terminals and roadways increase. Over 95 percent of the airports with less than a million originating passengers a year were providing curb space using a single level terminal building. Almost 40 percent of the airports with 1 to 2 ½ million originations have single level terminals. Only 25 percent of the airports with 2 ½ to 5 million originations and less than 5 percent of the airports with over 5 million originations have single

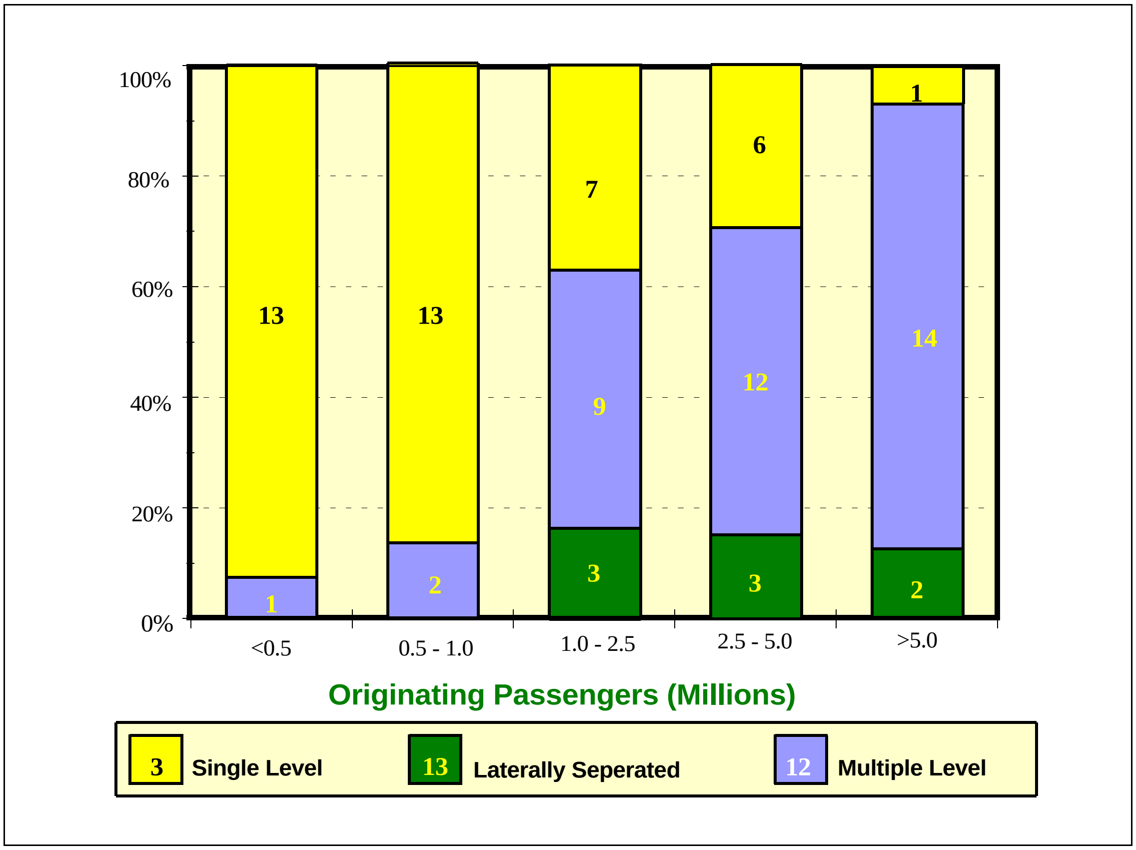

Figure 4: Airport terminal designs

level terminals. It was also noted from this analysis that 40% of the airports with less than 500,000 originations per year provide multiple curbsides through horizontal separation and supplemental curbside areas. This increases to over 60% of the airports with more than 5 million originations. Some airports, such as Boston Logan airport, have multiple curbside and terminal configurations that are provided at different terminals.

Parking Requirements

Since private automobiles are the primary mode used to access airports, parking needs can be expected to be directly related to the number of originating passengers. Parking supply data for over 85 airports was analyzed to determine if such a relationship exists.[7] Figure 5 clearly demonstrates that airport parking supply increases with originations and indicates that a direct relationship may exist.

Mode of Access to U.S. Airports

Data on mode of access to airports was assembled from the most recent passenger surveys at 35 U.S. airports. Figure 6 provides the minimum, maximum, and median percent of passengers who access different size airports via high occupancy modes (i.e., rail, bus, van, limousine). Even though a clear cut relationship cannot be identified from the available data, several observations about mode of access to airports can be made from Figure 6. The proportion of passengers who use high occupancy ground access modes to reach an airport generally increases as originations

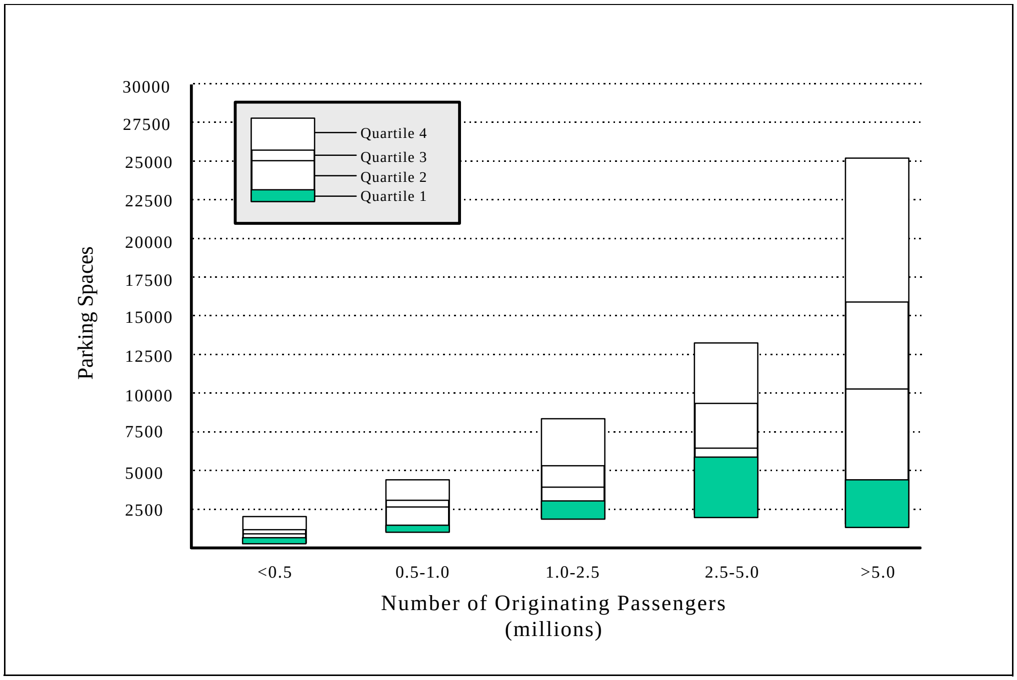

Figure 5: Parking requirements

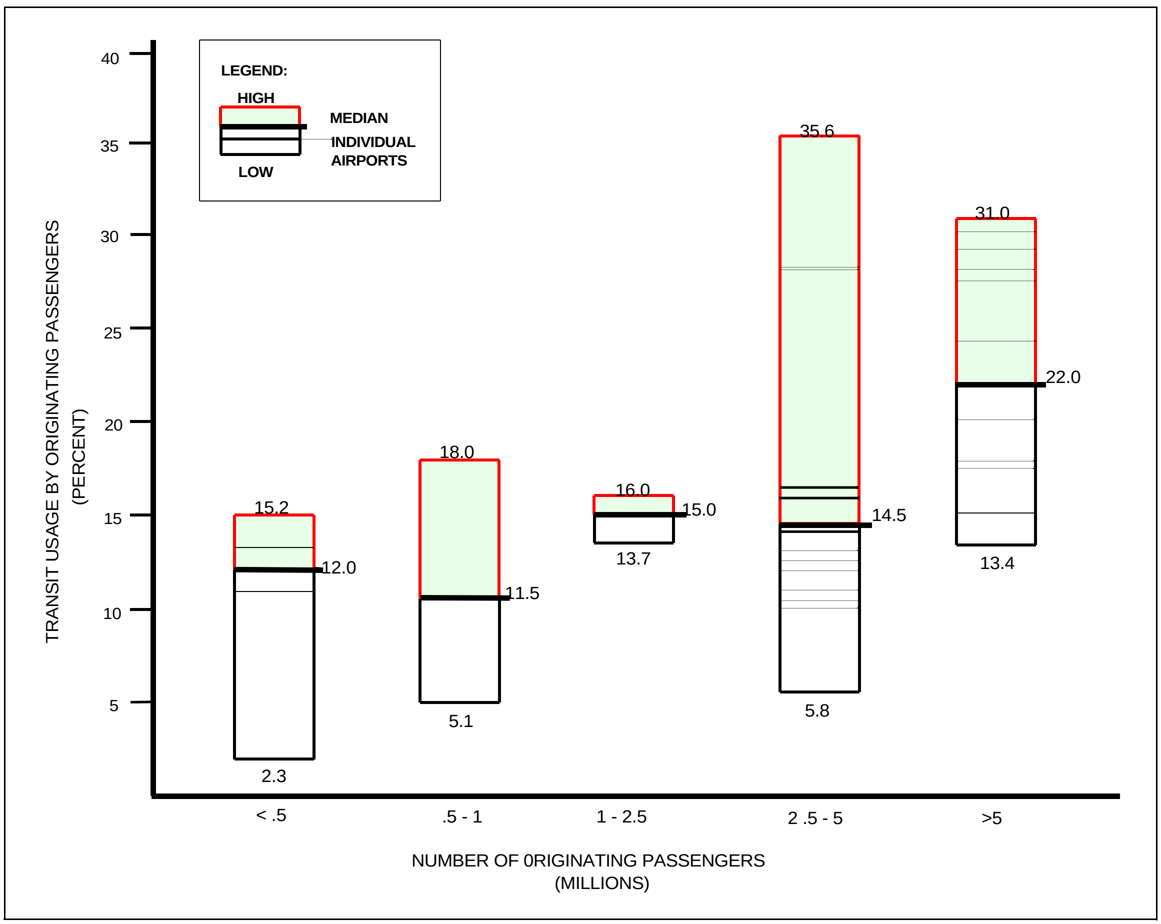

Figure 6: HOV use at U.S. airports

increase: the median value for access by a high occupancy mode at airports with less than five million annual originations is in the range of 11 to 15 percent, and the median for airports with over five million annual originations is 21 percent. The maximum transit use for airports with less than 2.5 million originations is 18 percent, and for airports with over 2.5 million originations is 35.6 percent.

Conclusion

Improved airport access facilities are becoming increasingly important to the efficient operation of an airport. The soon to be published *Intermodal Ground Access to Airports: A Planning Guide* provides rules of thumb, techniques, and data that can be used by planners, engineers and airport operators for groundside access planning. This *Guide* represents the existing state of the practice, and sets the stage for continuing development of airport groundside access data and analysis techniques.

FHWA and FAA are distributing the *Guide* to MPO's, Airports and others to help them perform access planning studies. FHWA and FAA will solicit feedback on this version of the *Guide* to determine its strength and weaknesses. While this *Guide* is a good start the need for some additional work related to this subject is already evident. Some suggestions for additional work include:

- Gather more data on airport access travel characteristics such as the number of ground access trips related to originations, employees, and cargo activity at different airports,
- The number of passengers traveling in each vehicle that enters an airport (vehicle occupancy).
- More information on peaking characteristics at different types of airports,
- Comparable guidance to the *Guide* for planning freight access to airports, and
- Development of better airport access related planning tools and models.

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A New Tool for Benefit-Cost Analysis in Evaluating Transportation Alternatives

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Abstract

The Intermodal Surface Transportation Efficiency Act (ISTEA) emphasizes assessment of multi-modal alternatives and demand management strategies. This emphasis has increased the need for planners to provide good comparative information to decision-makers. Benefit-cost analysis is a useful tool to compare the economic worth of alternatives and evaluate trade-offs between economic benefits and non-monetizable social and environmental impacts. In 1995, the Federal Highway Administration (FHWA) developed a sketch planning tool called the Sketch Planning Analysis Spreadsheet Model (SPASM) to assist planners in developing the type of economic efficiency and other evaluative information needed to compare across modes and demand management strategies, at a sketch planning level of analysis for corridor studies. When more detailed analysis is required, however, SPASM cannot be used directly, owing to several simplifying assumptions. (For example, all trips are assumed to be of an average trip length, made between the two ends of the corridor.) Also, it is difficult to use SPASM for systemwide analysis. (Note: We presented a paper on use of SPASM at the Small and Medium-Sized Urban Area Conference in October, 1996).

To allow more *detailed* analysis at both the system and corridor levels, FHWA has developed an enhanced version of SPASM. There are several significant improvements. First, the software accepts input directly from the four step travel demand modeling process or from off-model software such as FHWA's TDM software. Second, it post-processes outputs from conventional four-step planning models, in order to get more accurate highway travel speeds, especially under congested conditions. Third, it performs risk analysis to clearly describe the level of uncertainty in the results of the analysis, so that the debate can shift from unproductive technical controversy to compromise and action.

The software is based on the principles of economic analysis, and allows development of monetized impact estimates for a wide range of transportation investments and policies, including major capital projects, pricing and travel demand management (TDM). Impact measures are monetized to the extent feasible, but quantitative estimates of natural resource usage (i.e. energy consumption) and environmental impact (e.g. emissions) are also provided. Net monetary benefits (or costs) of alternatives can then be used to evaluate trade-offs against non-monetizable benefits, including sustainability and community livability.

This paper provides a case study application of the enhanced software in evaluation of corridor alternatives and system plan alternatives for Toledo, Ohio. The case study demonstrates that the new software can be a useful tool in providing information of interest to decision-makers.

The Intermodal Surface Transportation Efficiency Act (ISTEA) emphasizes assessment of multi-modal alternatives and demand management strategies. This emphasis has increased the need for planners to provide good comparative information to decisionmakers. Benefit-cost analysis is a useful tool to compare the economic worth of alternatives and evaluate trade-offs between economic benefits and non- monetizable social and environmental impacts.

In 1995, the Federal Highway Administration (FHWA) developed a corridor sketch planning tool called the Sketch Planning Analysis Spreadsheet Model (SPASM) to assist planners in developing the type of economic efficiency and other evaluative information needed for comparing cross-modal and demand management strategies (DeCorla-Souza, Cohen & Bhatt 1996). When more detailed analysis is required, however, SPASM cannot be used directly, owing to several simplifying assumptions. For example, all trips are assumed to be of an average trip length, made between the two ends of the corridor. Also, it is difficult to use SPASM for systemwide analysis. To allow more *detailed* analysis, FHWA has developed an enhanced version of SPASM, called the Surface Transportation Efficiency Analysis Model (STEAM). The software is currently undergoing field testing.

Overview Of STEAM

There are several significant improvements in STEAM. First, the software accepts input directly from the four-step travel demand modeling process or from off-model software such as FHWA's TDM software (Comsis 1993). Second, it post-processes traffic assignment outputs from conventional four- step planning models, in order to more accurately estimate highway travel speeds, especially under congested conditions. Third, it performs risk analysis to clearly describe the level of uncertainty in the results of the analysis, so that unproductive technical controversy over unit values or demand estimates can be avoided. Finally, its impact estimates are systemwide, not limited to the improvement corridor.

The software is based on the principles of economic analysis, and allows development of monetized impact estimates for a wide range of transportation investments and policies, including major capital projects, pricing and travel demand management (TDM). Impact measures are monetized to the extent feasible, but quantitative estimates of natural resource usage (e.g., energy consumption) and environmental impact (e.g., emissions) are also provided. Net monetary benefits (or costs) of alternatives can then be used to evaluate trade-offs against non-monetizable benefits.

STEAM is highly flexible in terms of the transportation modes, trip purposes, and time periods analyzed. It provides default analysis parameters for seven modes (auto, truck, carpool, local bus, express bus, light rail, and heavy rail) and allows the user to deal with special circumstances or new modes by modifying these parameters. The user can also provide trip tables for different trip purposes, which will be analyzed separately by the model. STEAM can be applied to average weekday traffic or to peak and off-peak traffic.

Case Study Analysis

We performed a real-world test of the software, using a case study evaluation of transportation alternatives for the I-15 corridor in Salt Lake City, Utah. In this section, we describe the alternatives analyzed, and procedures used to develop the needed input data. In section 4.0, we discuss impact analysis procedures embedded in the software, and present results of STEAM's impact analysis. In section 5.0, we discuss STEAM's economic efficiency analysis procedures, and results from the case study analysis.

Corridor Alternatives

The limits of the case study corridor are defined by the interchanges of I-15 with the I-215 loop north and south of the city. The corridor is about 12 miles in length. Significant growth is expected in the Salt Lake City region, and in the corridor in particular. Population in the corridor is anticipated to increase by more than 100% while employment is estimated to increase by more than 140% over the next 20 years. This growth is expected to significantly affect traffic flow in the corridor. Traffic on I-15 in the southern portion of the corridor is expected to double.

In a 1995 study (USDOT 1995), four transportation alternatives were proposed for the corridor. For this case study demonstration, we used two of these alternatives (i.e., “No-Build” and “Full Build”), and designed a third alternative, i.e., a “Travel Demand Management (TDM)” alternative, for the purpose of demonstrating the application of the software in TDM analysis. The three alternatives are as described below.

- Do-Nothing or “No-Build” alternative: This alternative included all new capacity projects in the region’s Long Range Transportation Plan, except for I-15 improvements. A planned light rail line in the I-15 corridor was included.
- “Build” alternative: This alternative involved the widening of I-15 to include two additional mixed- flow travel lanes in each direction. The section of the I-15 freeway to be expanded currently has 6 lanes, 3 in each direction.
- “TDM/Tolls” alternative: This alternative primarily involved introduction of a $1.00 toll to be collected on I-15 through automated collection techniques at both ends of the corridor (i.e., at each of the two I-215 interchanges), and at all entrance ramps within the corridor. No highway capacity improvements were included. A 25% increase in both bus and light rail service was included, to handle increases in transit demand due to “tolled off” auto users.

Developing STEAM Inputs from Demand Models

STEAM uses as input the following output from the four-step travel demand modeling process: (1) person and vehicle trip tables; (2) travel time and cost matrices skimmed from transit and highway networks; and (3) loaded highway network output from traffic assignment.

Travel demand model outputs for the two action alternatives and the No-Build alternative were obtained from runs of the four-step travel demand models developed by the Wasatch Front Regional Council (WFRC). The models were run using WFRC’s 2015 Transportation Plan and its 2015 socio-economic forecasts for the WFRC region. For the TDM alternative, we re-coded the highway network to reflect an in-vehicle time penalty equivalent to the toll. The demand modeling procedures are presented graphically on the left side of Figure 1. Both trip table and loaded highway network outputs were obtained for a 24-hour time period. The transit time and cost skims reflected peak period service.

Defining Market Sectors

Market sectors for use in STEAM analysis are defined by trip mode, purpose, and time of day. Since the Salt Lake City models produced daily demand estimates, market sectors were defined only by trip mode and purpose. The travel demand models produced person trip tables by mode (auto, bus, walk-accessed light rail and drive-accessed light rail) and vehicle trip tables, for the following four internal trip purposes: Home-based (HB) work, HB non-work, HB college, and Non-HB. Additionally, vehicle trip tables were generated for the following three trip purposes: internal truck, internal-external, and through. For HB work person trips, an additional mode, i.e. “Carpool” was estimated by the models.

Since internal-external and through trips include both passenger and truck travel, the first step would be to break down these two trip tables into auto and truck modes. For Salt Lake City, the truck share of these trips was unknown, so all trips were assumed to be auto mode trips. To run STEAM with Salt Lake City trip tables could potentially require running each of the market sectors shown below:

Trip Purpose	Auto mode	Carpool	Bus	Walk to Light Rail	Drive to Light Rail	Truck
HB work	X	X	X	X	X	
HB college	X		X	X	X	
HB non-work	X		X	X	X	
NHB	X		X	X	X	
Internal truck						X
Internal-external	X					potential
Through	X					potential

To reduce the number of market sectors to be analyzed, the seven trip purposes were collapsed into two: (1) a personal travel purpose and (2) a commercial (truck) purpose; i.e., all non-truck trip purposes were combined into a single "personal travel" purpose, since we planned to use the same values of time and other user benefits irrespective of trip purpose. The resulting market sectors are displayed below:

Trip Purpose	Auto mode	Carpool	Bus	Walk to Light Rail	Drive to Light Rail	Truck
Personal travel	X	X	X	X	X	
Internal truck						X

Developing Market Sector Inputs

Auto-occupancies for the personal travel auto and carpool modes were obtained by dividing the sum of regionwide person trips by the sum of vehicle trips for each mode. For the non-highway personal travel modes (bus and rail), average occupancies were estimated from passenger count information. For these modes, travel time "skim" tables and out-of-pocket cost tables were additionally needed. The demand models generated the in-vehicle travel time skims. The models also generated walk skims and wait skims, which were summed by origin-destination pair to get out-of-vehicle travel time skims. The models directly generated out-of-pocket cost skims (in cents) based on transit fares.

Impact Analysis Procedures

As shown on the right side of Figure 1, STEAM consists of four modules:

1. A *User Interface Module*, which includes on-line help files and tutorials.
2. A *Network Analysis Module*, which reads a file containing volumes, segment lengths, capacities, and other link data and produces zone-to-zone travel times and distances based on minimum time paths through the highway network.

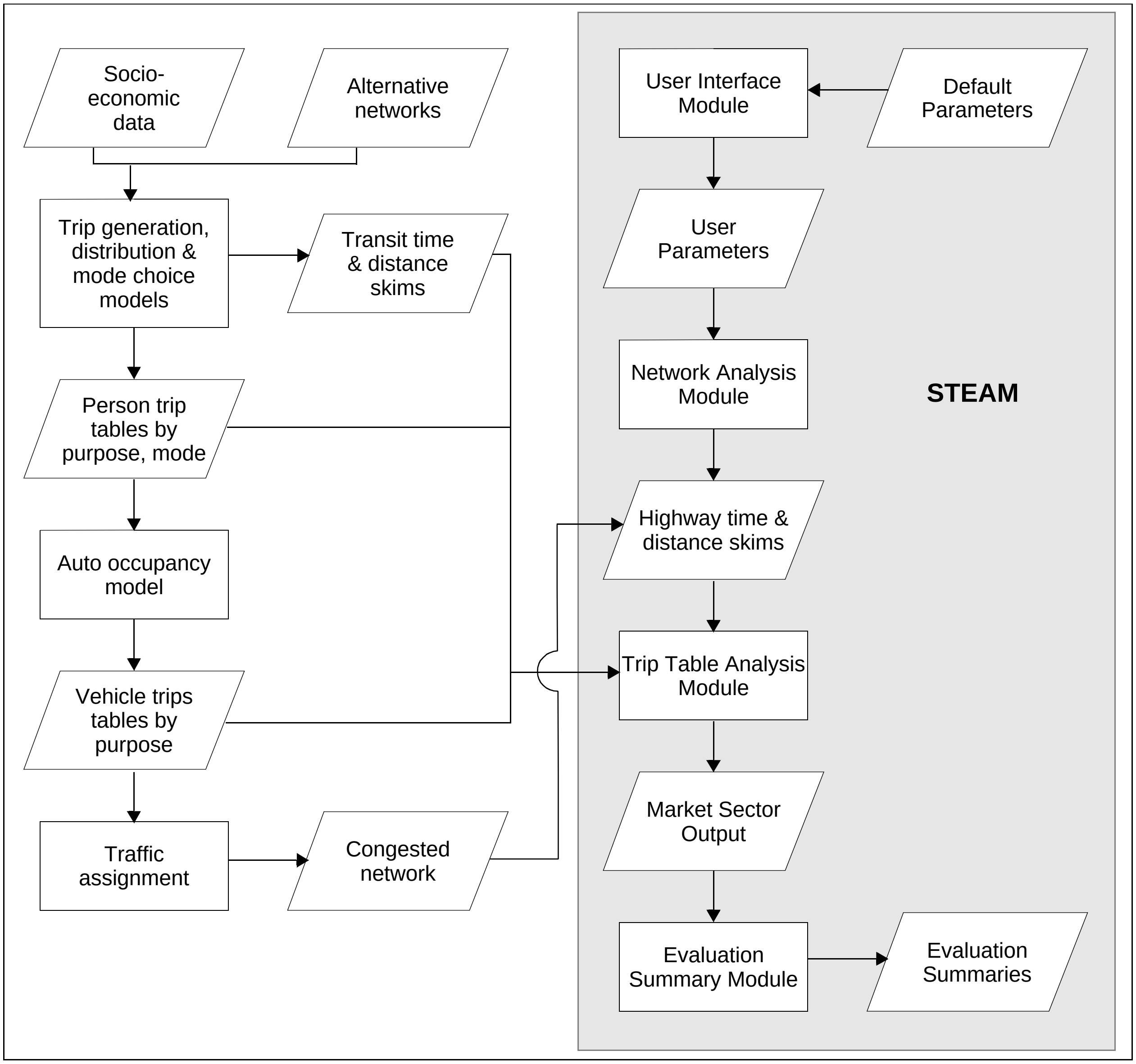

Figure 1: Overview of analysis procedures

3. A *Trip Table Analysis Module*, which produces estimates of user benefits based on a comparison of Base Case and Improvement Case conditions. It also produces estimates of emissions, noise costs, accident costs, energy consumption, and other external costs associated with highway use.

4. An *Evaluation Summary Module*, which calculates net present worth and a benefit-cost ratio for the improvement under consideration. It also provides summary information on individual benefit and cost items.

In this section we discuss the speed estimation procedures used in the Network Analysis Module, and procedures used in the Trip Table Analysis Module to estimate emissions and energy consumption.

Estimating Travel Speed

As a user option, STEAM estimates travel speeds based on procedures which relate average weekday traffic-to-capacity ratios (AWDT/C) to average hourly delay and speed (Margiotta et al. 1996). The procedures incorporate the dynamic effects of queuing and peak-spreading which are not considered when conventional Highway Capacity Manual (HCM) procedures (TRB 1994) are used with assigned traffic volumes.

To develop these speed relationships, hour-by-hour traffic for typical facilities was first estimated based on the flattening of the diurnal distribution of traffic that occurs in response to increasing levels of congestion at higher AWDT/C ratios. The hour-by-hour traffic estimates were then used to obtain hour- by-hour estimates of congestion delay using the traffic microsimulation models FRESIM and NETSIM (Makemson et al. 1993). The speed relationships thus developed account for spreading of traffic from congested time periods to uncongested time periods, as well as queuing impacts on traffic speeds in successive hours. The procedures thus provide a simple and straightforward method to estimate speeds with greater accuracy, without having to resort to complex peak-spreading and microsimulation models.

Emissions Analysis

The conventional link-based emissions analysis approach cannot easily be used to estimate the changes in cold start emissions that may result from demand management actions (DeCorla-Souza et al. 1994). STEAM therefore uses a trip based approach to estimate emissions. In STEAM, emissions for autos, trucks and carpools are calculated as the sum of: (1) emissions due to vehicle miles of travel (VMT), calculated under the assumption that vehicles are already warmed up, i.e., in either the hot-start mode or hot-stabilized mode; and (2) added emissions due to cold starts.

Non-cold start emissions are calculated using emission rates as a function of speed. The added emissions due to cold starts are calculated on a per vehicle trip basis. STEAM allows the user to specify the fraction of vehicle trips starting cold for the peak and off-peak periods; national defaults are provided from recent research (Venigalla, Miller and Chatterjee 1995).

Default emission rates in STEAM for non-cold-start operations were calculated using MOBILE5A by setting the cold start VMT fraction equal to zero, the hot start VMT fraction equal to 0.479 and the stabilized VMT fraction equal to 0.521. The default emission rate due to each cold start in STEAM was calculated by subtracting the gram per mile value (at 26 mph) under hot start conditions from the gram per mile value (also at 26 mph) under cold start conditions, and multiplying the result by 3.59 miles.

Fuel Consumption Analysis

Increases or decreases in use of motor fuel are estimated by STEAM by vehicle type (auto and truck) as a function of speed, using fleet average fuel consumption rates (Cohn et al. 1992).

Impacts of Case Study Alternatives

Table 1 summarizes travel demand estimates by mode for the whole region, obtained from WFRC travel demand models. Auto person trips include both solo-driver and carpool trips; and transit person trips include both bus and light rail trips. The table also provides estimates from STEAM of average regionwide vehicular travel speeds, emissions, and fuel consumption.

Economic Analysis Procedures

All benefits are computed by STEAM's Trip Table Analysis Module based on weekday travel estimates for a specific analysis year. Weekday benefits are annualized assuming 250 working days per year. (This may be modified by the user). The analysis year may be selected by the user to be representative of benefits over the analysis period, i.e., the life of the investment. Alternatively, the user may run STEAM with data for several different analysis years, and estimate the stream of benefits over the life of the investment. STEAM analyzes the benefits of transportation actions by market segment.

Table 1: Travel demand, emissions, and average speeds

	No-Build	Build	TDM/Tolls
Weekday Person Trips (in millions)			
Auto	5.721	5.721	5.708
Transit	0.091	0.090	0.102
Truck	0.018	0.018	0.018
Total	5.828	5.828	5.828
Weekday Vehicle Trips (in millions)			
Auto	4.231	4.231	4.224
Truck	0.018	0.018	0.018
Total	4.249	4.248	4.242
Weekday Vehicle Miles (in millions)	27.767	27.958	27.452
Avg. Auto Speed (mph)	18.24	18.98	18.32
Annual Emissions (tons)			
Hydrocarbons (HC)	23,388	22,865	22,648
Carbon Monoxide (CO)	194,765	190,225	181,746
Nitrogen Oxides (NO_x)	15,417	15,535	14,695
Annual Fuel Use (million gallons)	410.42	406.30	402.81

User Benefits

User benefits are calculated for each zone-to-zone trip interchange. Benefits include savings in user costs such as travel time costs, vehicle operating costs and out-of-pocket costs for fares, parking (if paid by the user) and tolls. User-perceived benefits are reduced as a result of increases in user costs. Since user payments for fares, fuel taxes and tolls represent monetary transfers (not a net increase in the resource cost of transportation to society as a whole), it is necessary to add these revenue transfers to total societal benefits of the actions under consideration.

User-perceived travel cost changes for vehicle operation are computed by STEAM based on VMT changes and on fuel consumption changes. STEAM uses a default variable vehicle operating cost of 3.4 cents for autos (CSI 1992) and 10 cents for trucks. The defaults for fuel cost are $1.20 per gallon of auto fuel and $1.10 per gallon of truck fuel. Note that these values include fuel taxes, which are transfers. Therefore, the tax revenues need to be considered as "benefits" to public agencies in the accounting for total societal benefits.

Travel time savings for personal travel (i.e. autos, HOV and transit) are monetized by STEAM using a value of personal travel time per hour provided by the user. STEAM's default is $6.00 per person hour, i.e., 50% of the national average wage rate (Miller 1989). The default value for out-of-vehicle travel time is $9.00, i.e., 1 ½ times the value of in-vehicle travel time. For commercial truck traffic, STEAM's default is $24.60 per hour based on national data (NHI 1995).

For new users of a mode (for each trip interchange), savings are valued by STEAM at one-half the rate used for former users, as suggested by consumer surplus theory (NHI 1995), since new users do not really save the full amount saved by former users, but approximately half. Former users are those users who used the specified mode under the No-Build scenario. New users are those users attracted to the mode, or to a new destination, due to facility or service improvements. Similarly, disbenefits are computed for users discouraged from a mode or destination.

Revenue Transfers

Fares, tolls and taxes are transfers from users to the government, and are not normally relevant in evaluation of economic costs and benefits for society as a whole, even though they are extremely important in demand estimation. However, since the imposition of fares, tolls and taxes causes a reduction in the user-perceived benefit estimates computed by STEAM, any changes in these revenues to public agencies must be added back into the computation of total benefits to society.

External Cost Changes

Accident costs are considered to be "external" costs because drivers do not generally take these costs into consideration in making a decision to drive. Moreover, accidents cause many costs which are not borne by system users directly (e.g., costs for public services such as police, fire and court systems, health insurance coverage which may be paid by employers, and pain and suffering caused to non-users). STEAM uses default estimates of fatality, injury and property damage only (PDO) accident rates by facility class, and default estimates of user-perceived and societal accident costs per accident (Miller 1991).

Many social and environmental impacts (i.e., both benefits and costs) cannot be monetized or even quantified, and must be described qualitatively for consideration by decision makers. For example, it is difficult to monetize benefits such as community livability, and it is difficult to monetize costs such as loss of historical resources. STEAM does monetize two types of impacts which are quantifiable -- air pollutant emissions and noise. STEAM permits the user to specify emission costs per ton of pollutant, and noise costs per VMT. STEAM's default monetary values for emission costs are based on recent research (Wang & Santini 1995). Default values of noise damage cost per VMT are based on FHWA research (Haling & Cohen 1996).

The user may provide estimates of other mileage-based external costs by facility class. These costs per VMT are multiplied by VMT to produce estimates of "other mileage-based" external costs. Non-mileage based external costs such as parking costs which are generally not directly borne by drivers (and therefore not taken into consideration in driving decisions) are not computed by STEAM, but must be provided as a lump-sum user input to STEAM called "other non-mileage based costs". The user may also provide estimates of construction period costs such as travel delay costs separately.

Public Agency Costs

Included in this category are all costs borne by highway and transit agencies. Capital costs and annual highway O & M costs must be input directly by the user. For construction costs, STEAM projects out to the year of opening to traffic the value of capital costs assumed to be incurred at the mid-point of construction, and then annualizes it based on the facility life. A default discount rate of 7%, as recommended by the Federal Office of Management & Budget (OMB) is used to

Table 2: Annualized benefits and costs (millions of dollars)

		Build
Annual Benefits		
User Benefits		135.39
Revenues to Public Agency (change)	Fuel taxes	-1.63
	Fares	-0.25
	Tolls	0.00
	Sub-total	-1.88
External Benefits/ Disbenefits	Accidents	-0.21
	Noise	-0.04
	Emissions	16.48
	Other non-mileage	-0.16
	Sub-total	16.07
Total Annual Benefits		149.58
Total Annual Public Agency Costs		
Capital		64.92
Operating		0.89
Total Annualized Costs		65.81
Economic Efficiency Measures		
Net Annual Worth		83.77
Benefit/Cost Ratio		2.27

annualize capital costs (OMB 1992). STEAM permits the use of alternative discount rates.

Transit operating costs are calculated by STEAM by applying cost per vehicle mile, cost per vehicle hour and cost per peak vehicle (input by the user) to the changes in transit vehicle miles, vehicle hours and peak vehicles, which STEAM estimates based on changes in transit travel demand and transit vehicle occupancy provided by the user.

Net Annual Worth

Net worth is calculated by STEAM by subtracting costs to public agencies from the total benefits (i.e., the sum of user benefits, revenue transfers, and savings in external costs). Benefit/cost ratios are also calculated. The numerator of this ratio is the total benefits. The denominator is annualized costs to public agencies. Net worth and benefit-cost ratios are indicators of the economic efficiency of the alternatives.

Case Study Benefits and Costs

Table 2 summarizes the annualized costs and benefits of the Build alternative. (At the time of writing, STEAM results for the Tolls/TDM Alternative were not yet available. User cost savings make up most of the benefits for the Build alternative -- $135 million.

Fuel tax revenue changes were estimated based on annual gasoline consumption changes from Table 1. Fare revenue changes were estimated based on transit ridership changes from Table 1. The increase in VMT in the Build alternative causes disbenefits in VMT-based external costs (i.e., accidents and noise). However, higher speeds result in net savings in emission costs of $16.5 million. Other non-mileage costs increase due to parking cost increases as a result of higher numbers of vehicle trips.

Public agency cost estimates are presented in Table 2 as differences with respect to the No-Build alternative. Capital costs include costs borne by transportation agencies for construction, engineering and rights-of-way (R-O-W). Opportunity costs of R-O-W already owned by the public agency (Utah DOT) were included in total R-O-W capital costs. A discount rate of 7%, as recommended by the Federal Office of Management & Budget (OMB 1992) was used to annualize capital costs. Costs for operation and maintenance (O&M) of added freeway mixed-flow lanes were estimated based on the 1995 study (USDOT 1995).

Table 2 also presents estimates of net annual worth (i.e., benefits minus costs) and benefit/cost (B/C) ratios. The Build alternative shows a net annual worth of $84 million. Net worth provides a useful measure in comparative evaluation of alternatives, *along with measures or clear descrip-*

tions of non- monetized social and environmental impacts, such as community livability and pride, neighborhood cohesion, aesthetics, energy security, global climate change effects, social equity and environmental justice. The net worth can be used by decision makers to assess whether other non-monetized disbenefits (or benefits) are worth the estimated net *economic* gain (or loss) to society for the alternative under consideration. If net worth is negative, it provides "scale" as to how large non-monetized benefits should be in order to move a project alternative into the acceptable range.

Conclusions

This paper has demonstrated a benefit-cost assessment at a detailed level of analysis for the Build alternative for the I-15 corridor in Salt Lake City, using FHWA's new software STEAM. Benefit-cost assessment was done on a multi- modal basis using output easily available from the four-step travel demand modeling process.

We are continuing efforts to refine STEAM based on feedback from beta-testing by practitioners. Also, a risk analysis component is being added to the software. There will always be considerable uncertainty about the input cost parameters, e.g., value of time. The risk analysis feature in STEAM will allow the user to input these values as a probability distribution. STEAM will then use Monte Carlo simulation techniques to calculate the probability that Net Worth will exceed values specified by the user. Such estimates are useful in forging consensus among diverse groups, each desiring that their own values be used in the analysis (Lewis 1995).

Disclaimer: We wish to emphasize that the case study analysis described in this paper has been performed for demonstration purposes only, and *the results do not necessarily represent impacts of any of the alternatives tested by Salt Lake City planners*. The views we have expressed in the paper are ours alone, and do not necessarily represent the views or policies of the FHWA or the US DOT.

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Analytical Methods to Support Performance-Based Transportation Planning

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Abstract

The paper and presentation will focus on the application of performance measures in multimodal transportation planning at the state and regional level. The authors have recently completed Phase I of NCHRP Research Project 8-32(2), Development of a Performance-Based Planning Process. This study explored past and current applications of quantitative performance evaluation to planning decision-making. In one of several focused areas of investigation, current methods of data collection, manipulation, and analysis were reviewed to assess their ability to support development of performance measures, beyond traditional measures of highway capacity and utilization such as v/c ratio and delay.

The study found that although multimodal measures of performance are gaining wider acceptance in the transportation planning profession, the actual experience in application falls short of conceptual frameworks. Difficulties have been encountered in several areas, notably in data collection and the inability to forecast less common data such as might be applied in measurement of system reliability, or goods movement, for example.

Methodological improvements are suggested to capitalize on more highly automated data collection and manipulation techniques resulting from deployment of “intelligent” technologies on highway and transit systems. In addition, improvements to demand forecasting and analysis models are suggested which will help provide the types of data needed to populate multimodal performance measures that highlight factors such as transportation system reliability, total throughput of persons or goods, or tradeoff between alternative modes.

A second phase of research on NCHRP 8-32(2) is expected to be well underway by the time of the Dearborn conference. This second phase will focus explicitly on the application of performance-based methods in a variety of case studies drawn from around the United States. Probable case studies will include examples of utilization of ITS-collected data for planning purposes, travel model improvements to generate performance indicators, public and private sector measurement of freight movement performance, and shared data resources. Examples from the Phase II research should be available for presentation and discussion at the conference.

In summary, Project 8-32(2) draws together elements from a variety of topic areas that should be of interest to conference attendees, including intelligent transportation systems, travel demand forecasting, data collection issues, and multimodal planning.

Variations In Predicted Employment-related Tripmaking Caused By Alternate Systems Of Job Classification

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Abstract

The purposes of this paper are to examine alternate classification systems of jobs, and to investigate how predicted volumes of employment-related trips vary according to the system used to classify jobs by type.

SEMCOG has obtained a special crosstabulation of 1990 census data on workers by traffic analysis zone of work. We have developed a method that uses industrial class and occupational class in conjunction to assign land use classes to the workers. This allows the linking of the workplace's land use class to the commuting trip characteristics (time of departure, trip duration, means of transportation) that are contained in the census crosstabulation.

In addition, in 1994 SEMCOG conducted a household travel survey, that covered 7,400 households in Southeast Michigan. This survey included questions on the industrial class, and the land use class, of each employed person's primary job. These items are linkable to the characteristics of the home-to-work trip, including time of departure and arrival, means of transportation, and trip end locations, collected by the survey.

The paper will contrast two systems of classifying kind of work or kind of job activity. One of these systems is industrial class, which relates to the overall purpose of the business, agency, or governmental department. Examples of general industrial classes are manufacturing, retail trade, services, and public administration. The other system is land use class, by which is meant the nature and characteristics of the activities, and usually also the buildings and associated open lands that the activities occupy, occurring at specific individual locations. Examples of general nonresidential land use classes include office, commercial, institutional, and industrial. To illustrate, an industrial class system would put the label retail trade on all the establishments and workers of the Kmart Corporation, whereas with a land use class system the headquarters would be called office, the stores commercial, and the warehouses industrial.

SEMCOG's transportation modeling has used industrial class employment data because that was the best available. Now that we have a new wealth of tripmaking data by land use class employment, we want to apply this information to our transportation models. We believe that grouping jobs by land use class may significantly improve the models' performance for several reasons. Should the findings of these comparisons support our underlying assumption that employment by land use class, rather than by industrial class, is a better predictor of employment-related tripmaking, SEMCOG will investigate the feasibility of creating new trip generation equations in our transportation model.

The purposes of this paper are to describe how the locational patterns of jobs, and the arrival time of home-to-work trips, vary according to the system used to classify jobs. SEMCOG has obtained a special crosstabulation of 1990 census data on workers by traffic analysis zone of work. We have developed a method that uses industrial class and occupational class in conjunction to assign land use classes to the workers. This allows the linking of the workplace's land use class to the worker's commuting trip characteristics (time of departure, trip duration, means of transportation) that are contained in the census crosstabulation.[1] The analysis is based upon data for workers whose jobs were in Oakland County, a portion of the Southeast Michigan region and located immediately north and west of Detroit City. In 1990 Oakland County contained nearly three-tenths of the seven-county region's 2.4 million total jobs.

The paper contrasts two systems of classifying kind of work or kind of job activity. One of these systems is industrial class, which relates to the overall purpose of the business, agency, or governmental department. Examples of general industrial classes are manufacturing, retail trade and services. The other system is land use class, by which is meant the nature and characteristics of the activities, and usually the buildings and associated open lands that the activities occupy. The paper uses five general nonresidential land use classes: office, commercial, institutional, industrial, and transportation, communications, and utilities, or TCU. To illustrate, an industrial class system would put the label retail trade on all the establishments and workers of the Kmart Corporation, whereas with a land use class system the headquarters would be called office, the stores commercial, and the warehouses industrial.

Degree Of Spatial Segregation

This section is concerned with the locational pattern of employment. Specifically, it examines the hypothesis that total jobs, when classified by land use class, will exhibit significantly higher degrees of spatial differentiation and separation then would the same total when divided by industrial class.

The first two figures address the locational pattern of employment. Each figure portrays the spatial distribution of a given land use class, and compares it to the distribution of each of the other four land use classes. Figure 1 is based upon office land use employment, and Figure 2 on industrial land use employment.

The x-axis of the two graphs gives a count of TAZs, arranged in an order that corresponds to the occurrence of workers in the base land use class, i.e., office, or industrial. The leftmost TAZ has the greatest number of workers in that land use, with the other TAZs arrayed in descending order.

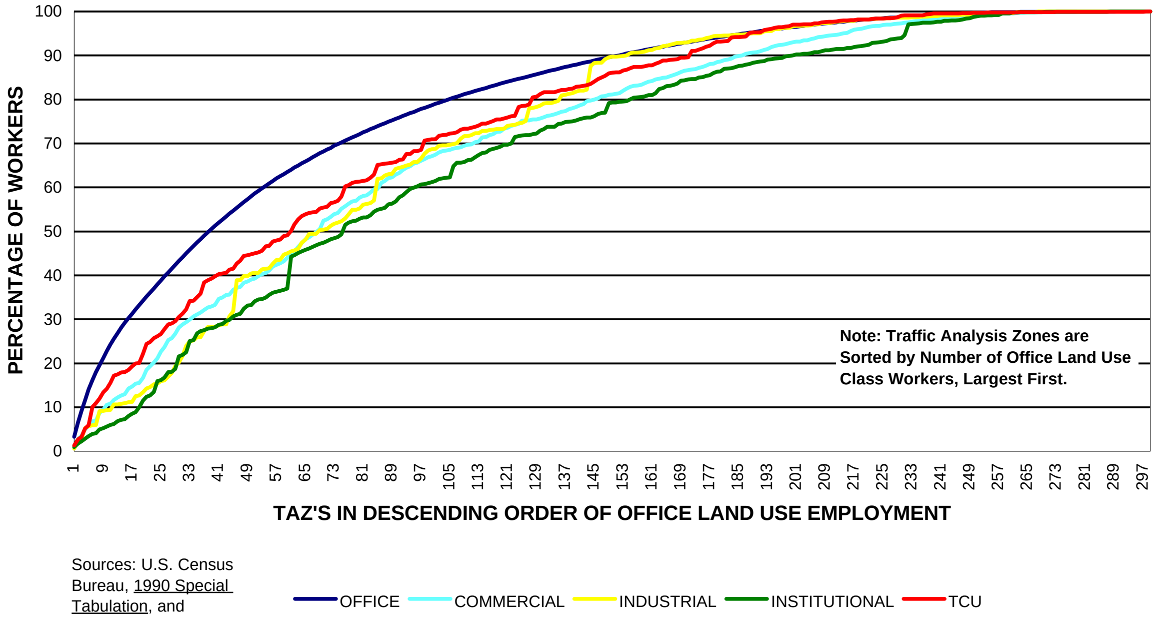
Each graph shows five curves, one for each of the five land use classes. The curves are cumulative, rising with the occurrence of workers of the given land use. In Figure 1 it is the office curve that ascends most rapidly and most smoothly, because the TAZs are arrayed by the percentage share of Oakland County office jobs that each successive zone contains. The same applies to the curve of industrial land use of Figure 2.

The slope of the base land use curve reflects the degree of concentration of that class of employment. For example, in Figure 1 the first 38 zones account for 50 percent of total county office employment, and the first 100 for nearly 80 percent. But industrial land use employment is even more concentrated. As shown in Figure 2, the 50 percent mark is reached by the 23rd zone and 80 percent is reached by the 70th zone.

The vertical distance between the base land use curve and any of the four other curves is an indication of the degree of spatial segregation between the base land use class and that other land use. For example, in Figure 1, for almost 90 percent of accumulated office employment, TCU is the curve closest to the office curve. (Keep in mind that post offices, an activity that is fairly compatible with office land use, make up roughly 20 percent of Oakland County's TCU employment). The distance between the two curves averages roughly 10 percentage points. The institutional

Figure 1

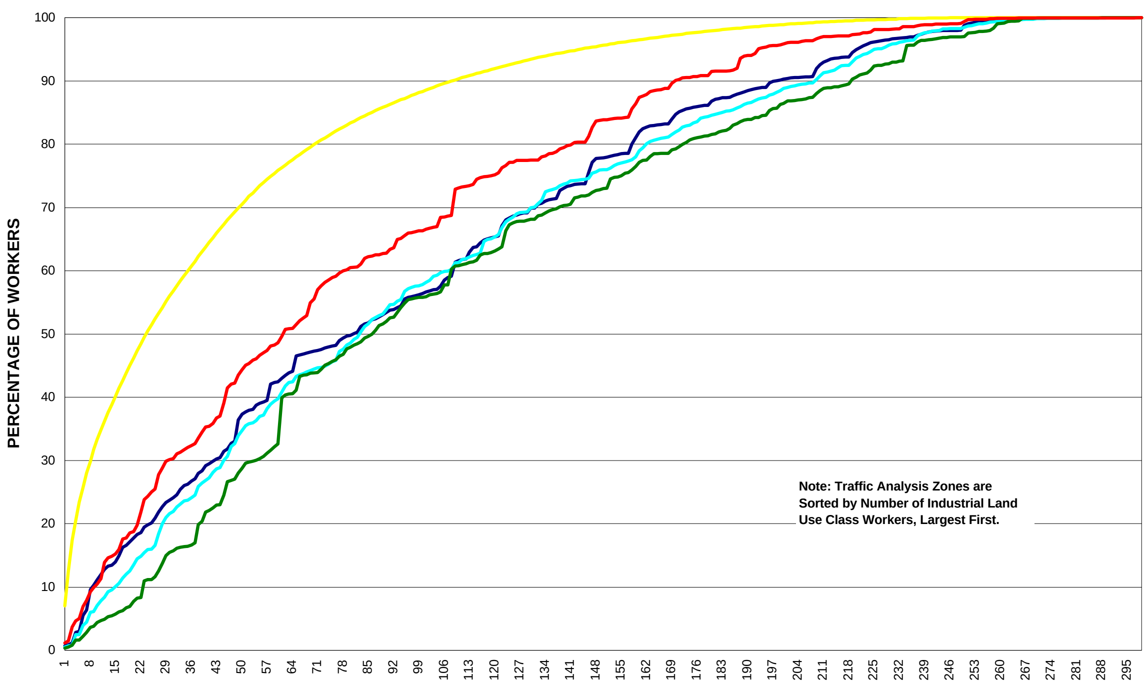
CUMULATIVE DISTRIBUTION OF WORKERS BY TRAFFIC ANALYSIS ZONE OF WORK, OFFICE LAND USE CLASS COMPARED TO FOUR OTHER LAND USE CLASSES, OAKLAND COUNTY, MICHIGAN:1990



Sources: U.S. Census Bureau, 1990 Special Tabulation, and SEMCOG.

Figure 2

CUMULATIVE DISTRIBUTION OF WORKERS BY TRAFFIC ANALYSIS ZONE OF WORK, INDUSTRIAL LAND USE CLASS COMPARED TO FOUR OTHER LAND USE CLASSES, OAKLAND COUNTY, MICHIGAN:1990



Sources: U.S. Census Bureau, 1990 Special Tabulation, and SEMCOG.

land use curve is the farthest from the office curve, the degree of separation averaging about 20 percentage points.

Figure 2 compares industrial land use employment to that of the other land uses. Note that as with the office employment curve of Figure 1, the TCU curve is closest to the industrial curve. (This probably represents the presence of “industrial-like” components, e.g. truck and rail terminals, within the TCU land use class). At its greatest, the separation between the two curves is around 25 percentage points. The remaining three curves, office, commercial, and institutional, have roughly the same degree of separation from industrial land use, about 35 percentage points at the maximum.

Time Of Arrival At Work

This section is concerned with the home-to-work trip. Specifically, it uses time of arrival at the workplace. Time of arrival can be seen as a measure of two phenomena: travel behavior of the workers, i.e., the time they choose to or must arrive at work, and work behavior of the business establishments, i.e., the Circadian rhythm of their operations.

The next three figures examine time of arrival at the workplace. The graphs show hours of the day along the x-axis, in one-hour intervals 6:00 a.m. to 7:00 p.m., and by multiple-hour intervals for the remaining eleven hours. The y-axis of each graph represents the percentage of total arrivals of the given class of employment. The curves are cumulative, rising with the percentage of workers of the given land use class arriving within the given internal. The curves use 6:00 a.m. as the starting line or zero point. Therefore, for example, workers arriving at 5:40 a.m. will be recorded in the rightmost interval of the graph.

Figure 3 portrays the time of arrival of workers of each of the five land use classes, as well as of all workers (shown as a heavy line). There are considerable differences among the six lines.

The total workers line shows that 50 percent of all workers arrive at work between 6:00 a.m. and just past 8:30 a.m., and 80 percent arrive by 11:00 a.m. Workers in institutional land use follow the same pattern almost exactly, except that there is a group that arrives somewhat earlier. No doubt this reflects the operational rhythm of hospitals, and elementary and secondary schools.

Industrial land use workers have the earliest pattern of starting work; more than one- fourth arrive between 6:00 a.m. and 7:00 a.m., and almost half by 8:00 a.m. A subsequent six hours of general plateauing is followed by a 15 percentage point rise between 2:00 p.m. and 5:00 p.m., as the second shift begins. Evidence of a third shift begins to appear after 7:00 p.m.

TCU land use employment shows a three-shift pattern similar to that of industrial land use, except that the TCU curve is five to ten percentage points higher from 9:00 a.m. to 3:00 p.m. This difference probably reflects the necessity for many TCU activities to be immediately responsive to demand, whether the demand be for the movement of persons, or information, or energy. The rhythm of industrial land use work is not as time sensitive, and so can be accommodated by a relatively larger second shift.

Of all the curves, the commercial is the slowest to rise during the first two hours. It is the last to reach the 50 percent mark, not reaching it until just past 9:30 a.m. This reflects the fact that many retail trade establishments do not open for business until 9:00 a.m. or later. The curve rises slowly until around 3:00 p.m., when it goes into a rapid rise, that continues until 6:00 p.m. This three-

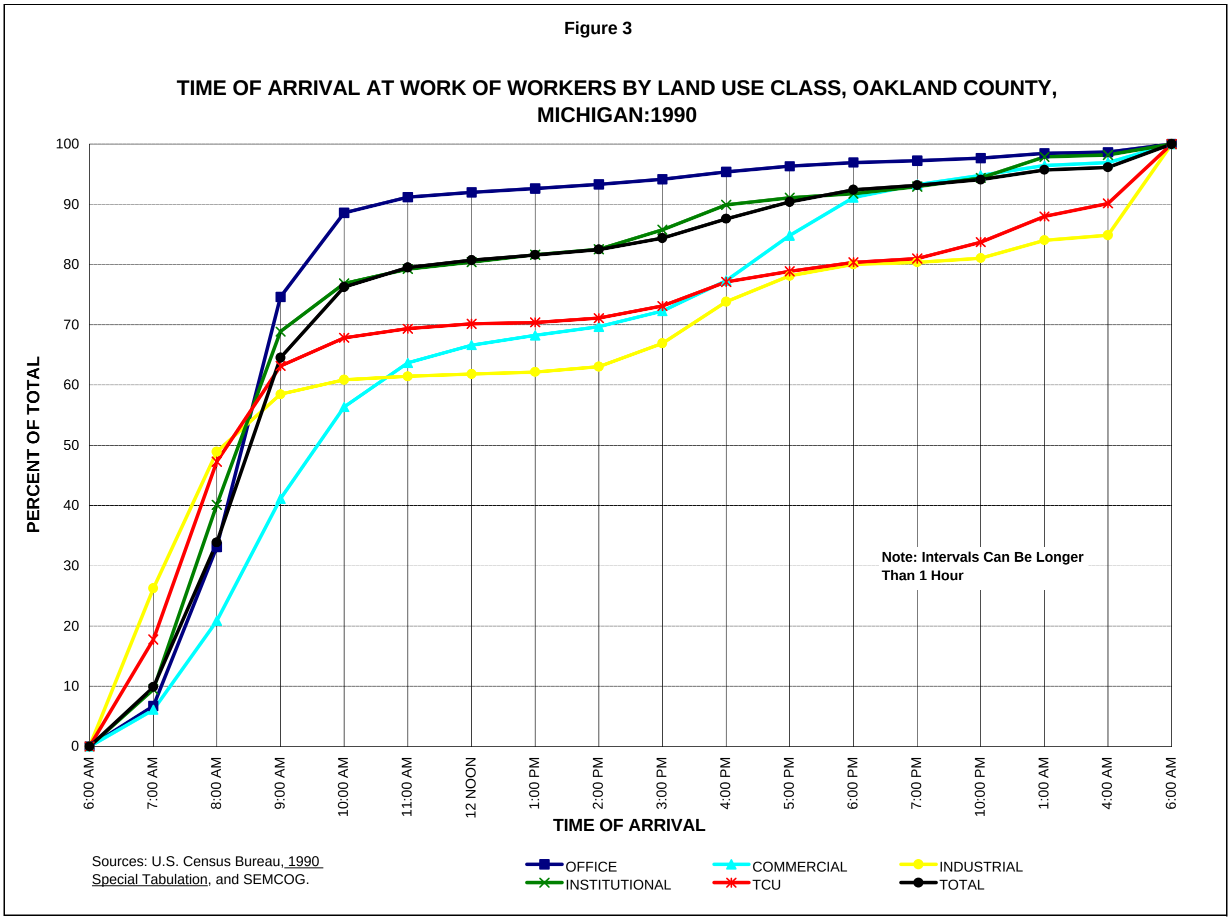


Figure 3

TIME OF ARRIVAL AT WORK OF WORKERS BY LAND USE CLASS, OAKLAND COUNTY, MICHIGAN:1990

hour spurt probably represents a response to shoppers who are getting out of work or school, as well as the evening peak period for eating, drinking, and entertainment establishments.

The office curve begins with a slow start. At 7:00 a.m. it is at only seven percent. It then rises very rapidly, reaching 50 percent around 8:30 a.m., and 80 percent around 9:30 a.m. From about 8:30 a.m. on, it is the highest curve on the graph. It reaches 90 percent at 10:30 a.m., and rises slowly and steadily after that.

These curves of the five basic nonresidential land use classes, as well as the curve of total employment, illustrate the time patterns of establishments' operations. The changing shape of each curve is easily explainable, because the changes correspond to our direct experience of the rhythms of urban area economic activities.

The next graph, Figure 4, illustrates time of arrival for workers in office land use. The heavy line represents total office employment. Note that it corresponds to the office land use curve on Figure 3. The eight other lines represent office land use employment in each of eight industrial classes.

The single most striking feature of the set of curves is how close they are to each other. The differences among them are not great, and are explainable. The manufacturing curve rises rapidly early in the morning because the manufacturing factories and warehouses — the industrial facilities being managed by the manufacturing offices — begin work early. The wholesale trade curve is

Figure 4

TIME OF ARRIVAL AT WORK OF WORKERS IN OFFICE LAND USE CLASS, TOTAL COMPARED TO EIGHT INDUSTRIAL CLASSES, OAKLAND COUNTY, MICHIGAN:1990

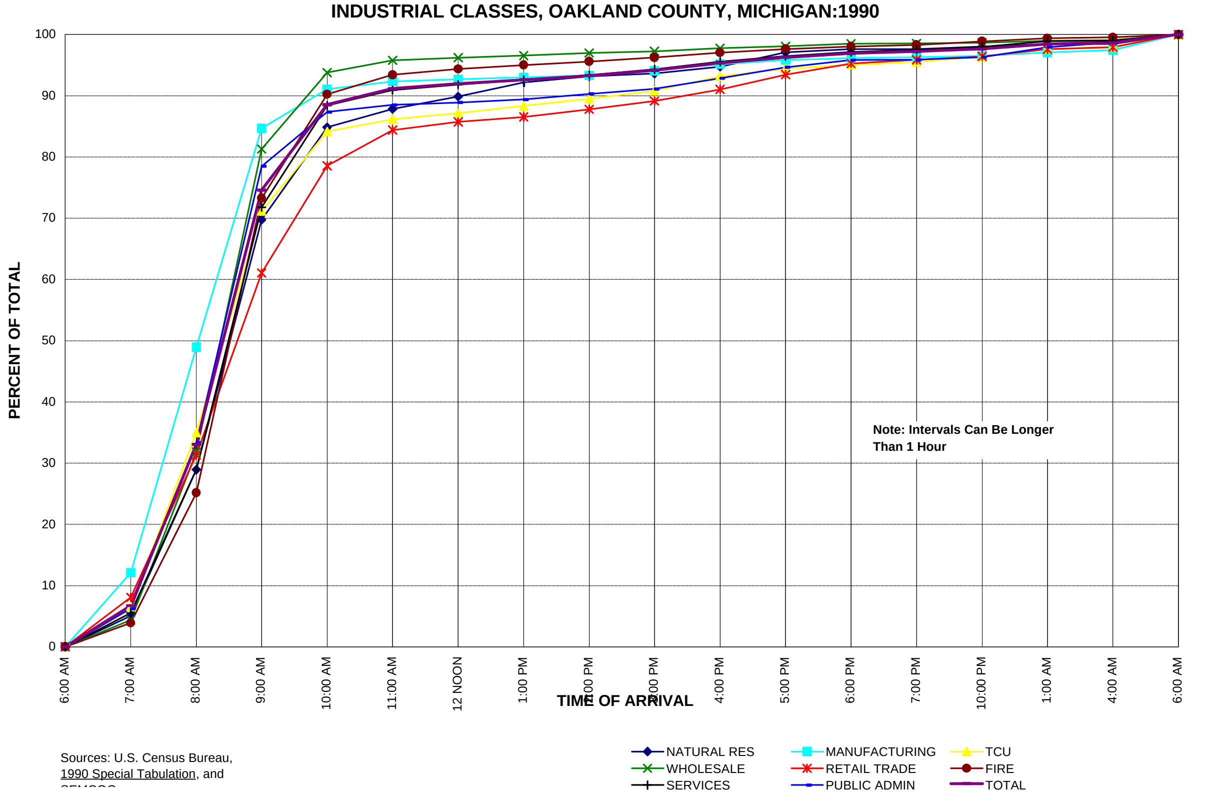
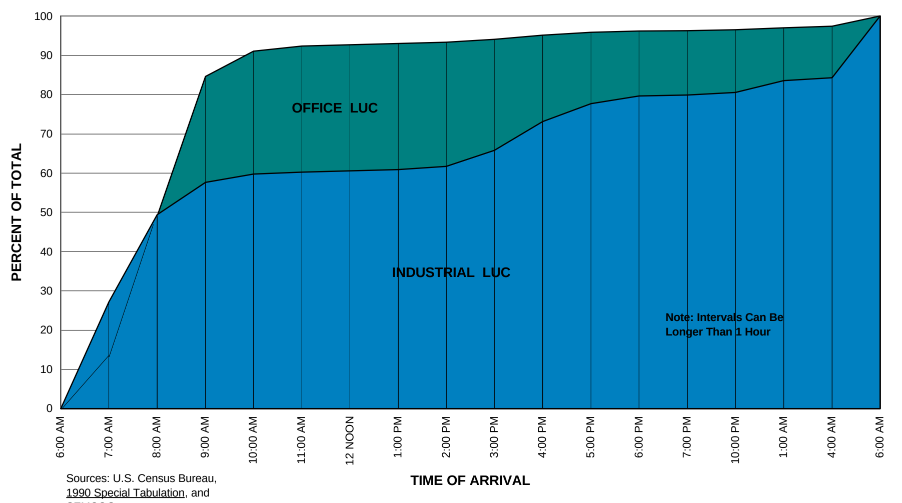


Figure 5

TIME OF ARRIVAL AT WORK OF WORKERS IN MANUFACTURING INDUSTRIAL CLASS, OFFICE LAND USE CLASS COMPARED TO INDUSTRIAL LAND USE CLASS, OAKLAND COUNTY, MICHIGAN:1990



high because office establishments in this industrial class are managing the deliveries that in many cases need to be arranged and completed during the daytime delivery hours that office and commercial establishments require. One the other hand, the retail trade curve is the lowest one across much of the graph because most stores and restaurants do much of their business during the afternoon and evening hours, so that's when management needs to be available.

Figure 4 indicates that overall, workers in office land use behave very similarly in terms of time of arrival at work. Office land use is the primary fact; industrial class is a secondary detail. Figure 4 provides evidence, in a time dimension, of the distinctiveness of each land use class. This evidence complements the spatial distinctiveness discussed earlier.

The final graph, Figure 5, contrasts employment in two land use classes, office and industrial, within a single industrial class, manufacturing. Both land use classes reach the 50 percent mark at 8:00 a.m., but after that there is a very striking divergence. The office curve continues its rapid rise, reaching 90 percent just before 10:00 a.m. After this the curve rises very slowly, probably reflecting building cleaning and maintenance workers, security guards, and evening data processing personnel. The industrial land use class is very different. After a six-hour long plateau, the curve rises again, reflecting the second shift, with some evidence of a beginning third shift at 10:00 p.m.

Conclusions

This paper has presented evidence that employment, when subdivided by land use class, shows greater degrees of differentiation than when it is subdivided by industrial class. The greater differentiation occurs both in the spatial dimension of job location, and in the time dimensions of worker tripmaking and business establishment operations. These findings will be further explored and developed, as they appear to have strong relevance for the modeling of both employment location and travel demand.

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Acknowledgment

The technical work described in this paper was financed in part through grants from the U.S. Department of Transportation Federal Transit Administration and Federal Highway Administration through the Michigan Department of Transportation, and local membership contributions.

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Process for Developing Consistent Revenue Forecasts for Use by MPO's

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Abstract

The Intermodal Transportation Efficiency Act (ISTEA) of 1991 contained requirements for Metropolitan Planning Organizations, MPO's to financially constrain their metropolitan transportation plans by comparing the estimated revenue from existing and proposed funding sources that can reasonably be expected to be available for transportation uses. In Texas' 25 MPO's no systematic approach for considering future revenues for long range planning presently exists.

As part of the Texas Department of Transportation's Plan, Transportation Systems-Business Process Retooling effort a process to provide consistent assumptions in forecasting future revenues for use by the MPO's in Texas was undertaken. The objectives of the process are to: 1) establish a consistent, systematic approach to financial forecasting for the MPO's and 2) establish procedures to communicate financial information used to develop financially constrained plans to TxDOT's District Offices and to the MPO's.

Providing a consistent systematic process for forecasting future revenue for transportation purposes for a twenty-year period entails developing statewide control totals for anticipated future revenue from federal and state sources used to fund transportation system improvements for the period providing a mechanism whereby this information can be disseminated to the MPO's and integrated into the transportation planning process.

This paper will describe the process used by the TxDOT-Plan Transportation Systems-Business Process Retooling team in developing a consistent systematic approach to financial forecasting for the States MPO's.

The Development of Financial Plans for Regional Transportation Plans - Methods, Data and Issues

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Southeast Michigan Council of Governments

Abstract

The Intermodal Surface Transportation Efficiency Act of 1991 requires that projects identified in a region's long range plan be financially constrained. As an MPO, SEMCOG, the Southeast Michigan Council of Governments, developed a plan that not only met the ISTEA requirements and served the needs of its member communities, but that also was consistent and comparable with forecasts developed by the state's other urban areas and with the state plan developed by MDOT, the Michigan Department of Transportation. This paper will describe the method, development of assumptions and databases and the validation of the forecast with local and state transportation agencies. SEMCOG focused on identifying and matching resources to meet the region's capital needs, which involved roadway, transit, non-motorized and intermodal projects. Future revenues were used to constrain the projects in the RTP, with unmet needs being defined as the shortfall of financial resources necessary to meet all needs identified in the deficiency analysis stage. In a survey that identified revenues resources, revenues were anticipated as being "available" from federal, state and local sources.

The forecast of federal funds focused on those available to local units of government in Southeast Michigan with the Michigan Department of Transportation being responsible for forecasting funds for state trunkline projects within the region. Historical data from pre-ISTEA years was identified and, with some manipulation of the data, made compatible with the federal-aid programs created by ISTEA in order to identify a trend in revenues.

Each year, the transit agencies, county road commissions, cities, villages and state department of transportation share state fuel taxes and vehicle registration fees credited to the Michigan Transportation Fund (MTF). Distribution reports have been provided each year in compliance with the state's "Act 51" requirements. SEMCOG developed an internal database to capture the financial information delineated in this annual report. It was decided that a simple regression of 25 year's information could provide a reasonable projection of future anticipated revenues from this source.

Ascertaining revenues derived from local non-user sources proved to be quite challenging. In addition to its federal and state revenue receipts, each local unit of government (i.e. county road commissions, cities, villages) has the ability to generate or assign its own revenues for transportation purposes. With well over 100 units of local government, there was a need to identify a single, uniform and reasonably comparable source of data. It was determined that the best source of information was contained in "Act 51" computerized databases. These annual databases were compiled by MDOT, based upon audited reports submitted by each local unit of government, in compliance with state Act 51 reporting requirements.

There were several barriers in performing a capital-only forecast. While federal revenues must be earmarked for capital projects, in general, the assignment of MTF and local revenues to capital projects are not as apparent. As such, it was necessary to develop a factor to approximate capital/operating expense portions of total expenses. Once again, the best source of information appeared to be the Act 51 reports. It was necessary to validate the information with the individual county road commissions, since it was the information that they had reported that was being captured.

If there is one thing that grabs the attention of most people in our society, particularly public policy makers and particularly those in transportation in the State of Michigan, it is money. Too often the question is, how are we going to pay for a system that is so important to our region's economy and so important to our daily lives. Governments at all levels trying to answer this question are caught between a "rock and a hard place". The "rock" is tax or user fee increases that are few and far between and the "hard place" is rapidly rising costs for delivering safe and efficient transportation services. The Financial Plan for the Regional Transportation Plan (RTP) is no different in terms of focussing the attention of public policy makers because it now requires the clear identification of future financial resources and proposed capital expenditures.

There are many facets to the Financial Plan for the RTP process in Southeast Michigan revolving around various modes and various governments at all levels. The Financial Plan consists of five major elements:

- Forecasts of federal-aid highway funds, revenues from the Michigan Transportation Fund (MTF), which is the depository for fuel user fees and vehicle registration fees, and local property-tax based revenues available to state, county and local governments;
- Forecasts of federal-aid transit funds;
- An assessment of the needs of the transportation system;
- A comparison of revenues with needs to determine the need for new revenues and;
- The identification of a regional investment strategy.

This paper focuses on the portion of the Plan dealing with the road system in our region under the jurisdiction of county road agencies, cities, villages and the Michigan Department of Transportation. The discussion will be on the methods, the scope of data collection and the many issues faced in preparing the financial plan. A brief description of the outcome of the financial planning process is also included here.

ISTEA and Clean Air Act Amendment Requirements

Recognizing the need for financial planning, the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 made financial planning a cornerstone of all regional transportation plans and transportation improvement programs. All such plans and programs prepared by metropolitan planning organizations must include a financial plan and must make the statement that the projects contained therein are constrained to revenues expected to be available. No longer will these documents be "wish lists" of projects that have no chance of being developed; they must be a realistic assessment of what the public agency can actually accomplish given a reasonable assessment of available funding. The financial analysis is to show available revenues and their sources with a comparison to proposed expenditures. Additionally, the required air quality conformity analysis must be based on a constrained plan.

Beyond the Requirements - Common Sense

Financial planning can be defined as the determination and balancing of relevant sources of anticipated revenues and expenses over a set period of time. It is generally required in order to:

- Improve resource allocation in the face of scarcity and competition among many communities and agencies;

- Expose the needs for increased funding and new sources beyond federal sources;
- Commit to projects supporting conformance (with air quality standards), preservation and congestion management;
- Improve cooperative decision-making in the context of greater flexibility and new resource options; and
- Introduce budgetary, cash-flow and life-cycle disciplines in place of traditional methods.

Financial planning is performed by just about all agencies or organizations that maintain a budget and regularly assess anticipated revenues and expenditures. It is a necessary activity in order to properly maintain the financial health of the organization and to use all revenues in an efficient manner. Above all, financial planning is just common sense. Anticipation of future needs and whether there will be sufficient revenues to meet these needs is a necessary and prudent exercise.

Environment for Financial Planning in Southeast Michigan

Governments at various levels in the region responsible for delivering transportation services are directly involved in this task. There are 138 cities and villages, six county road commissions and one county department of public service in the region that have direct legal responsibility for maintaining the safety and efficiency of public streets and roadway systems. County road commissions are a particularly strong form of government in Michigan. Their jurisdiction covers some major and minor arterial roads in incorporated cities and villages and all public roads, including subdivision streets, in unincorporated areas. Road commissions have no taxing power but do receive an allocation of Michigan Transportation Fund revenue and have the ability to incur debt to fund improvements. They are also eligible to receive federal funds and can enter into agreements with other local units of government for road improvement programs. Of course the Michigan Department of Transportation also has significant responsibilities for the state trunkline system in the region.

Total route mileage in the region for roads under public jurisdiction is 21,496 (18% of the statewide roadway system). These roads range from Interstate freeways to primary arterials to subdivision streets. Of these, the county road commissions are responsible for over 10,600 miles and the Michigan Department of Transportation is responsible for approximately 1,300 miles. Cities and villages are responsible for the remainder. In addition to maintaining roadways, these agencies are responsible for 3,549 bridges in the region. The Michigan Department of Transportation is responsible for 1,936 bridges (54%); county road commissions maintain 1,215 (34%) and the cities and villages are responsible for 398 (12%).

Transit agencies are eligible to use federal-aid funds from the Highway Trust Fund for capital projects through the flexibility provided in ISTEA. There are five transit agencies in the region that are eligible; the Suburban Mobility Authority for Regional Transportation, the Detroit Department of Transportation, the Blue Water Area Transportation Commission, the Livingston Essential Transportation Service and the Lake Erie Transportation Commission.

Basic Steps in the Financial Plan

The methodology for the Financial Plan consists of the following nine steps:

- Surveying traditional funding sources for all modes at all levels of government;
- Collecting and reviewing data that describes the historical trends in revenues;
- Choosing an appropriate method for forecasting funds;
- Identifying appropriate assumptions to guide the forecast;
- Conducting the forecast and reporting results;
- Local government review and comment on forecast results;
- Identifying needs, proposed solutions and relevant costs;
- Comparing available revenues with proposed expenditures and developing an investment strategy and;
- Identifying unmet needs of the transportation system.

Much of this work entailed a review of the groundwork laid for the initial Financial Plan in 1993. Much of the work surveying funding sources and collecting data was accomplished in earlier work, although the data were updated where possible. The forecasting method was reviewed to determine whether it remained appropriate. And among the tasks key to the success of the financial plan was the review and comment by affected state, county and local governments. New for this Plan was the identification of the unmet needs, that is, those projects that were excluded due to a lack of funds.

Scope of Data

The financial planning task was limited to using data from existing sources as resources did not exist for new data collection. For the federal fund portion of the forecast, the annual reports on Highway Statistics published by the Office of Highway Information Management of the Federal Highway Administration were the main sources for federal revenue and expenditure data. Unpublished reports prepared by the local office of the Federal Highway Administration were also used. These reports contained apportionment and allocation data for all federal-aid highway programs for the State of Michigan and the formula for distributing funds for individual programs to all urban and rural areas in the state. The Michigan Department of Transportation also provided supporting documentation for these data.

Annual data on revenues were collected for the 1978 to 1995 period for the state and the region. Specific programs included the pre-ISTEA Federal Aid Urban System, Federal Aid Secondary, Hazard Elimination and Rail Grade Crossings programs and the 85 Percent Floor Funds. Data on the Surface Transportation Program and the Minimum Allocation and Donor State Bonus programs were also collected.

The Transportation Economic Development Fund (TEDF) is also a major source of revenue for roadway and transit projects and so is a major element of the Financial Plan. This is a state program that includes a portion of federal Minimum Allocation and Donor State Bonus funds coupled with set-asides of state user fee revenue from the MTF and driver license fee revenue from the state general fund. The Michigan Department of Transportation provided data on the annual transportation budget that identified the specific contributions to the TEDF.

Sources of Revenue for the Michigan Transportation Fund

In most states, state government has established a mechanism for collecting and distributing user fee revenues for improving all public roads. In Michigan, Public Act 51 of 1951 (as amended) directs the collection and distribution of revenues. The Act identifies sources of funding including fuel user fees, vehicle registration fees, driver license fees, interest on revenues, motor carrier fees, toll road and crossing facilities revenues and miscellaneous sources. These revenues are deposited in the Michigan Transportation Fund created by Public Act 444 of 1978 which amended Section 10 of Act 51. The MTF is the successor to the Motor Vehicle Highway Fund created by Act 51. In 1992 the State of Michigan created the Local Program Fund (LPF) as part of the Build Michigan Program. This program receives revenues from a set-aside from the MTF (before distribution) and from a second set-aside from the State Trunkline Fund, and currently receives $33 million annually from the MTF.

Distribution of MTF Revenues

The distribution of MTF revenues includes initial set-asides for administration and collection costs, a rail-highway grade crossing account, and the state contributions to the Critical Bridge program and the Transportation Economic Development Fund. The balance of revenues are distributed to the Comprehensive Transportation Fund (10%) for transit and to the State Trunkline Fund, county road commissions, cities and villages (90%). Over the years, these statutory percentages have varied widely, but they currently stand at 39.1 percent for the State Trunkline Fund, 39.1 percent for county road commissions and 21.8 percent for cities and villages. The revenues for road commissions, cities and villages are then distributed to individual jurisdictions by factors including primary and local road mileage and population. LPF revenues are distributed to counties, cities and villages in the same manner as regular MTF distributions.

Within certain limitations, communities can use MTF distributions for either capital improvements or operating and maintenance expenses. The Michigan Department of Transportation's audited Act 51 databases from 1970-1993 was the best source of information describing these trends. This database represented an extensive array of expenditure items and accounting procedures. The analysis focused on capital expenditures, drawing upon the definitions incorporated into these reports. Capital expenditures ranged from construction of new roads on a new location and widening of existing roads to the reconstructing or resurfacing of existing roads and paving of gravel roads. The approach for determining financial needs for various activities assumes, for the purposes of this forecast, that the share of revenues needed for operating and maintaining the roadway system at the local level in the future will be approximately the same as current trends. This share is in the range of 75 to 80 percent.

This analysis centered separately on county road commissions and on cities and villages. Data for all road commissions and all cities and villages in the state were included in the analysis. Our initial analysis of the Act 51 Financial Reports indicated that historically, approximately 35 percent of cumulative expenditures for county road commissions, cities and villages in the state were capital in nature. Unfortunately, it was not practical to perform further micro-level analysis of information obtained from this data source, given data limitations, including constraints with the state's accounting system with respect to mapping project level detail to the Act 51 reports. Therefore, we further refined our analysis by conferring with each county's Federal Aid Committee. Using the macro level information as a point of departure, reiterative meetings allowed us to better ascertain local communities' trends. This additional analysis provided us with further information that was considered by all parties as being much closer to the communities' actual experience. This process allowed us to refine our capital expenditure factor considerably, to approximately 22 percent of total revenues.

Our final analysis indicated that estimated MTF revenues attributed to capital projects increased from $20.2 million in 1970 to $56.6 million in 1993, a 180 percent increase over the entire period, or approximately 8 percent per year (nominal dollars). While revenues generally increased, brief periods of decline were due to oil embargoes and economic downturns. The periods of increasing revenues can be attributed to economic upturns, increases in the state gasoline tax rate, and increases in travel, brought about by changing land use patterns. Finally, since 1984 vehicle registration fees have become an ad valorem tax, contributing to the revenue increase.

Sources of Revenue for Local Funding

Cities and villages in the State of Michigan have the ability to raise revenues primarily through their power to tax property, although this is strictly limited by the state constitution. No community is permitted to assess a vehicle registration fee or to assess its own gasoline tax.

Their power is typically manifested through special millages for roadway improvements, property tax revenues deposited into capital improvement programs or special assessments on property for special roadway maintenance or improvement projects. Cities and villages also have revenue raising capacity through debt instruments, mainly the sale of bonds. Typical county road commission sources may include contributions from local units of government and special assessment districts. Some road commissions also accumulate interest on investments of MTF.

As with the analysis of MTF expenditures, data pertaining to transportation revenues at the local level were obtained from audited Act 51 data files. However, given data limitations, we were constrained to data for a five year interval from 1990 through 1994. The stream of local revenues dedicated for capital improvements to the transportation system has not been constant. City and village revenues range from a high of $17.03 million in 1991, to a low of $13.81 million in 1990. Similarly, county road commission revenues have ranged from a high of $12.47 million in 1992 to a low of $9.23 million in 1994. Furthermore, when analyzed at the individual community level, the revenue stream was quite inconsistent, often with very high revenues in a given year, followed by several years of lower revenues. It has been suggested that these fluctuating patterns of revenues are due to communities' saving their funds over a period of time for a large project.

A capital expenditure factor was developed, similar to the MTF analysis, approximating expenditures for capital improvements. The same process was repeated, first with macro level analysis followed by interaction with the county level Federal Aid Committees. As was the case with the MTF analysis, this additional analysis provided us with information that was much closer to the communities' actual experience, yielding a capital expenditure factor of 20 percent.

Project Costs

Cost data for transportation projects were also reviewed during the planning process. These were stated in terms of per-mile and/or per-location costs. The Regional Transportation Improvement Program (TIP) Database was the primary source for these data. The Database contains project programming for all roadway projects in the region since 1992. While the actual costing of projects was conducted by the sponsoring agency, these data were assessed against TIP data to assure the reasonableness of the estimates.

Forecast Methodology

Various methods of forecasting revenues were considered during the initial planning process in 1993, including the use of trend analyses, more complex econometric models and component analysis. All of these methods have advantages and disadvantages. However, among the major considerations in choosing an appropriate method were technical integrity, ease of application, compatibility with available data and the ease of understanding the method and outcome by local governments. The method chosen for the federal fund forecast was a trend analysis applied to statewide revenues coupled with the application of a component element that calculated revenues to each urban area in the state and also the rural areas. The MTF forecast used a trend analysis while the local revenue forecast used simple averaging due to limitations of available data. This is discussed below.

The trend analysis for federal funding employed a relatively simple regression equation to "straight line" the historic trend in annual revenues, seen in Figure 1, to the year 2020, the horizon for the Regional Transportation Plan. Once these annual forecasts were determined, the component analysis applied the percentage shares stipulated in ISTEA, shown in Figure 2, and state legislation to determine available revenues to the regions and to the Michigan Department of Transportation. Figure 2 shows the percentage splits for the distribution of STP, Interstate Reimbursement, Minimum Allocation, Donor State Bonus and 90 Percent of Payments for FY 1997. In this manner the STP Urban program, for example, remained financially constrained at the state

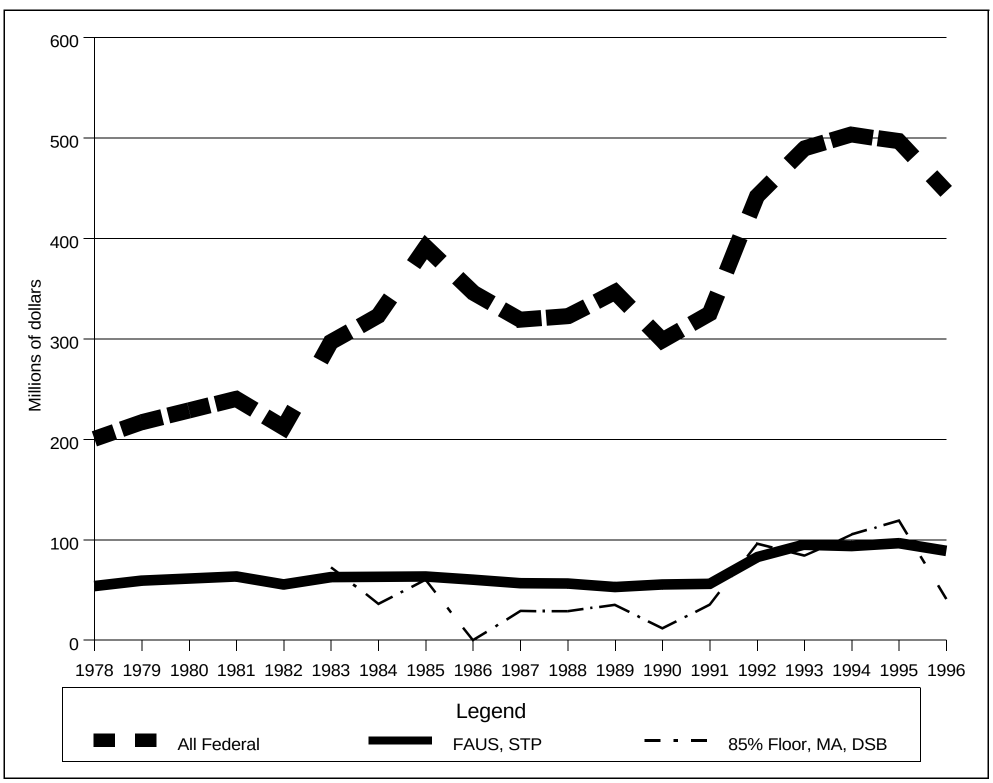

Figure 1: Historical trend in Federal Funds for the State of Michigan FY 1978-1996 (millions of nominal dollars)

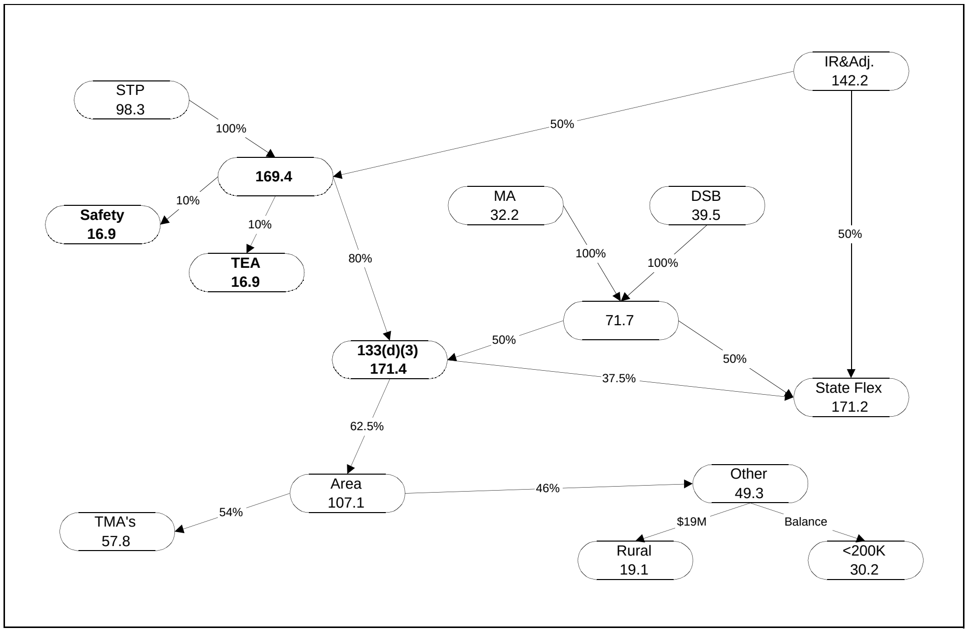

Figure 2: Distribution of STP, Interstate, Minimum Allocation, Donor State Bonus funds and 90 Percent of Payment funds, State of Michigan (FY 1997)

level.

The assumptions to any forecast are the backbone to a full understanding of the outcome. The assumptions for the federal fund forecast described below were developed with the intent of presenting the conditions under which historical revenues were generated and to suggest that future revenues will likely be generated under these same conditions. More specifically, the assumption dealing with socioeconomic factors refers to economic trends that affect travel demand such as gross domestic product, population, employment, personal income, household income and the price of gasoline. These factors affected the generation of revenues in the historic period and it is assumed that these same relationships, while not specified here, will continue during the forecast period. The following are the assumptions to the federal revenue forecast.

- The trend in user fee rates for gasoline and diesel fuel will continue (rates increased from 4 cents per gallon in 1978 to 18.4 cents per gallon in 1995);
- No change in the method of revenue distribution;
- Federal taxes on fuel and sales taxes on trucks, trailers and tires are extended beyond their current expiration date;
- No change in federal/state fund matching requirements;
- Limited or no erosion of revenues due to use of untaxable/alternative fuels;
- The future rate of change in socioeconomic factors affecting the transportation demand will follow historic trends.

The forecast resulted in the identification of $1.3 billion in federal funds available for capital improvements to the roadway system and nonmotorized paths and $570.1 million in revenue for transit capital expenditures. The Michigan Department of Transportation identified $4.3 billion available for trunkline system improvements in the region. These estimates are stated in 1996 dollars in order to remain consistent with cost estimations stated in 1996 dollars.

Forecast of Michigan Transportation Fund Revenues

As with the federal revenue forecast, a linear trend model was used to forecast all future revenues. It was decided to apply twenty-four years' information in projecting the future anticipated revenues from this source. Generally, there was an upward trend over this period of time, with MTF revenues attributed to capital projects increasing from $20.2 million in 1970 to $56.6 million in 1993, a 179.9 percent increase over the entire period, or approximately 8 percent per year. These data are in nominal dollars and do not reflect the true purchasing power of the revenues.

In preparing the model, certain assumptions were considered an inherent part of the forecast:

- Changes in fuel tax rates will be consistent with historical rate modifications;
- No changes in the external distribution formula of Act 51;
- Future rate of changes in socioeconomic factors affecting transportation demand will be based on historical trends;
- The LPF will be reauthorized at $33 million per year;
- Limited or no erosion due to use of untaxable or alternative fuels.

Historical information was captured at the county road commission, city and village level, and forecasted on a county-wide basis, with the City of Detroit forecasted separately. The MTF was forecasted to provide $1.5 billion in revenues (1996 dollars) for the twenty-five years covered by the Plan. Due to the decline in purchasing power over time, these revenues decrease from $319.8 million in the 1996-2000 interval to $268.3 million in the 2016-2020 interval.

Forecast of Local Tax Revenue

The forecast of local tax revenues was based on the sources and data introduced previously. It was assumed that local communities would continue to provide funding for transportation projects at least at the same rate as was done historically. Further analysis of the data indicated that unlike the MTF revenues which have been comparatively stable, the revenue stream from local sources, particularly when analyzed by individual community, has been quite inconsistent. The data suggest that often some communities will provide a very high level of funding for transportation purposes in a given year. This would either be preceded or followed by several years of lower revenues.

Due to this fluctuation in revenues and the relatively short historical period, and to the data constraints, it was decided that an averaging of five years' historical revenues was preferred to a forecast based on historical trends, and was most comparable. As with the MTF forecast, only those revenues that were determined to be associated with capital expenditures were forecasted. These revenues were forecasted at a level of nearly $660.8 million, or almost $132 million per each five year increment. This would cover all county road commissions, departments of public services and 138 cities and villages in the region for twenty-five years. This equates to an annual average expenditure of $182,000 per year.

Implementation of the Forecast

The draft revenue forecast was distributed to representatives from the seven counties in Southeast Michigan and the City of Detroit for their review, comment and suggested changes. These representatives included managers, engineers and finance professionals who have extensive experience in the financial management aspects of transportation system development. The forecast was adjusted through this task to more accurately reflect local financing practices as long as the reason for adjustment was clearly documented. This was particularly important in the determining the split of user fee revenues dedicated to operating and maintenance activities versus capital expenditures.

Once a final set of revenue figures were agreed upon, local governments were subsequently constrained to these revenues in the submission and prioritization of transportation projects for the Regional Transportation Plan.

The input of local government, that is those agencies and communities legally responsible for the safety and efficiency of the transportation system, was considered crucial to a successful financial plan.

Regional Investment Strategy

The data shown in the table below summarize the total cost of all projects proposed for the Regional Transportation Plan. They represent projects from county road commissions, cities, villages, regional transit agencies and the Michigan Department of Transportation. These agencies propose to spend approximately $8.9 billion in federal and non-federal funds to address the bridge, pavement preservation, non-motorized, congestion, safety and transit capital needs of the transportation system in Southeast Michigan.

A closer examination of the proposed spending shows that, in terms of percentages, the largest share is for pavement preservation with 50.0 percent. Pavement preservation includes resurfacing or total reconstruction of roadways, streets and highways. Bridge rehabilitation comprises an additional 17.6 percent. This work includes a wide variety of activities ranging from resurfacing bridge decks to total reconstruction. With safety projects included at 7.1 percent, a full 75 percent of proposed spending will be on preserving the existing system. This is significantly higher, almost double, the proposed expenditures as scheduled in the Regional Transportation Improvement Program since 1993.

Congestion mitigation projects, i.e. roadway widening of at least one through lane, comprise only 16.8 percent of proposed spending. The Transportation Improvement Program shows that 29 percent of scheduled projects involved roadway widening. Road agencies consequently propose to reduce their spending on these types of projects by close to 42 percent. A major conclusion from these data is that the Michigan Department of Transportation, county road commissions and local communities are placing a greater emphasis on preserving the roadway system than they have in the recent past.

The regional transit agencies are also showing significant investments in transit capital improvements. Proposed spending in the RTP is, at 8 percent, a continuation of the recent trend as shown in the Transportation Improvement Program.

Regional investment strategy for the transportation system, Federal and Non-federal funds (thousands of 1996 dollars)

	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020	Total	Percent of Total
Bridge Rehabilitation	284,172	298,073	290,776	341,717	342,810	1,557,548	17.6
Nonmotorized Facilities	10,046	9,128	8,188	7,061	6,724	41,147	0.5
Pavement Preservation	772,464	1,507,818	694,198	733,838	715,760	4,424,078	50.0
Safety Improvements	121,585	118,004	120,231	130,923	135,531	626,274	7.1
Congestion Mitigation	485,429	332,289	312,793	182,230	178,831	1,491,572	16.8
Transit Capital Purchases	112,805	164,230	146,799	115,249	176,327	715,410	8.0
Total	1,786,501	2,429,542	1,572,985	1,511,018	1,555,983	8,856,029	100.0

Forecasting Issues

As may be expected, a number of issues arose during the planning process that required significant attention. The first was the need to understand that the forecast was about other people's or agency's money, actually public tax dollars. The heightened interest of the public and elected officials as to how these funds are spent in the state also dictated the need to be clear and concise. This was considered by allowing sufficient time for review and comment of the forecast. A second issue involved the extent of the use of locally raised revenues for transportation purposes. Conflicts arose between data indicating that local governments use property-tax based revenue for capital projects and community officials who indicated precisely the opposite. A proposed future study of the how local revenues are used for transportation services in Southeast Michigan will attempt to answer this question. Many local officials were highly skeptical of forecasting for a twenty-year horizon, although they understood the requirement. While it appears the requirement will remain, the next Financial Plan will be expanded to provide a more detailed five-year investment strategy as a subset of the twenty-year Financial Plan.

One major issue centered on the assumed split of revenues from state and local sources used for operating and maintenance activities versus capital projects. The split was based on analyses of expenditure data as reported by the responsible agency. Difficulties arose in the interpretation of the data, despite the care taken to follow the accounting definitions accompanying the data and the assistance of finance staff from the Michigan Department of Transportation. A working group of local officials has been proposed to study this question and provide guidance for the next Financial Plan.

Summary

Many of the professionals we worked with during this planning process asked the question, "why are we doing this?" That came to be a tough question to answer and is the epitome of the challenge we faced. However, at the same time in our region, this process made local officials stop and think about what they are doing for the future of improving the transportation system. Using the Regional Transportation Plan as a forum, they are now discussing projects among themselves, making tough decisions on setting priorities for transportation funding.

However, we must continue to work to make financial planning for our plans and programs make sense. We must realize it is more than a technical exercise of forecasting revenues and expenditures. It is an exercise in cooperative decision-making among governments to provide the best transportation system possible.

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Adaptable Assignment

William G. Allen, Jr.

Abstract

This paper reports on a practical, simple method for adjusting a vehicle trip table so that the resulting assignments more closely match available traffic counts. "Practical" means that this is not purely a research effort — the procedure described here has been used in several studies as production-ready tool. "Simple" means that no special programming is necessary — the method can be implemented using existing travel modeling software packages. This procedure does not create a trip table directly from only traffic counts, but rather adjusts an existing table.

Over the years, researchers have developed a number of procedures which claim to synthesize travel patterns (i.e., a trip table) more or less directly from a set of traffic counts. This has great appeal to transportation planners, who are often faced with the task of quickly developing a traffic forecasting procedure based on little except a zone system, a network, and some counts (and sometimes, not even that much). However, most of these methods have not been successfully transferred to real world practitioners. Those few techniques that are in use are often viewed as "black boxes" that use obscure, complex algorithms and/or specialized software.

The method discussed here avoids elaborate algorithms in favor of a more easily understood "brute force" approach. The process requires the construction of minimum paths and the summation of the total count and total assigned volume (on links with counts) for each O-D pair. This information can readily be used to adjust the trips in each O-D pair. By iterating the process many times, dramatic improvements in the root-mean square assignment error can be achieved without unduly distorting the original trip table. This has been implemented as a simple multi-step procedure using the MINUTP software package; it may be possible to apply the procedure using other packages as well. The process results in a "delta" trip table, representing the difference between the original and adjusted trip tables. This delta table can be used by itself in forecasting or as the basis from which a model can be adjusted.

This procedure has been used in several cities in New Jersey and Pennsylvania, with satisfactory results.

This paper reports on a practical, simple method for adjusting an existing vehicle trip table so that the resulting assignments more closely match available traffic counts. "Practical" means that this is not purely a research effort — the procedure described here has been used in several studies as a production-ready tool. "Simple" means that no special programming is necessary — the method can be implemented using an existing travel modelling software package. This procedure does not create a trip table directly from only traffic counts, but rather adjusts an existing table.

Over the years, researchers have developed a number of procedures which claim to synthesize travel patterns (i.e., a trip table) more or less directly from a set of traffic counts. This has great appeal to transportation planners, who are often faced with the task of quickly developing an assignment procedure based on little except a zone system, a network, and some counts (and sometimes, not even that much). However, most of these methods have not been successfully transferred to real world practitioners. Those few techniques that are in use are often viewed as "black boxes" that may use obscure, complex algorithms and/or specialized software.

For example, The Highway Emulator (THE) software package incorporates a “trip table from counts” methodology. TMODEL2 also includes this feature, using an algorithm based on Willumsen’s Method. Cambridge Systematics has developed a program it calls “TTE” for this purpose. These methods all use some variation of an iterative proportional fitting technique. The TRIPS software package uses a sophisticated mathematical programming technique in its MVESTM procedure to estimate trip tables. The EMME/2 and TransCAD packages reportedly also include such procedures.

The method described here, called *adaptable assignment*, takes a different approach. Instead of elaborate algorithms, it uses a very simple “brute force” set of calculations. Instead of a black box compiled program, it uses a straightforward set of modelling steps, which any reasonably capable software package should be able to perform.

One of the dangers of *any* kind of trip table estimation process is that it can lead to distorted and unrealistic trip patterns, depending on the count coverage and the starting trip table. With adaptable assignment, the process is simple and open and the analyst can easily check the results at any point in the process. This makes it much easier for the analyst to ensure that the resulting trip table is not unreasonable. Also, since the process can be applied using standard software, the extra cost of specialized programs is avoided. With continuing advances in microprocessor speed, brute force methods become increasingly feasible.

Methodology

Adaptable assignment is an iterative procedure by which an assignment is made, the resulting assigned volumes are systematically compared to the counts, trip table adjustment factors are developed and applied, and the process repeated. As developed thus far, there is no means of automatically stopping the process based on some criterion of convergence, but it should be possible to add that feature at a later date. Thus, the analyst must specify a fixed number of iterations and include a step to calculate and display whatever convergence statistic is desired.

As described here, the procedure has been implemented using the MINUTP software package. The process uses one special feature of MINUTP, but it may be possible to implement the process within other packages, such as TRANPLAN and EMME/2. The process is implemented as a DOS batch file, which runs a series of four MINUTP steps through several iterations. Thus far, it appears that 10-20 iterations provides an acceptable trade-off between accuracy and processing time. Continuing advances in microprocessor speed make it increasingly feasible to run numerous iterations of this procedure, and the process can be entirely automated via batch files and can run unattended.

The four main steps of the procedure are as follows:

Step 1: Traffic Assignment

The analyst must begin with a highway network and a starting vehicle trip table. The trip table can represent daily or peak hour trips, but must be consistent with the counts that are posted in the network. The trip table can come from any source: calibrated gravity model, synthesized gravity model, previous year’s trip table, travel survey, etc. Obviously, the more confidence the analyst has in the starting trip table, the better the results. However, it is believed that even a poorly synthesized trip table based on estimated land use, approximate trip rates, and borrowed F factors, should be an acceptable starting point.

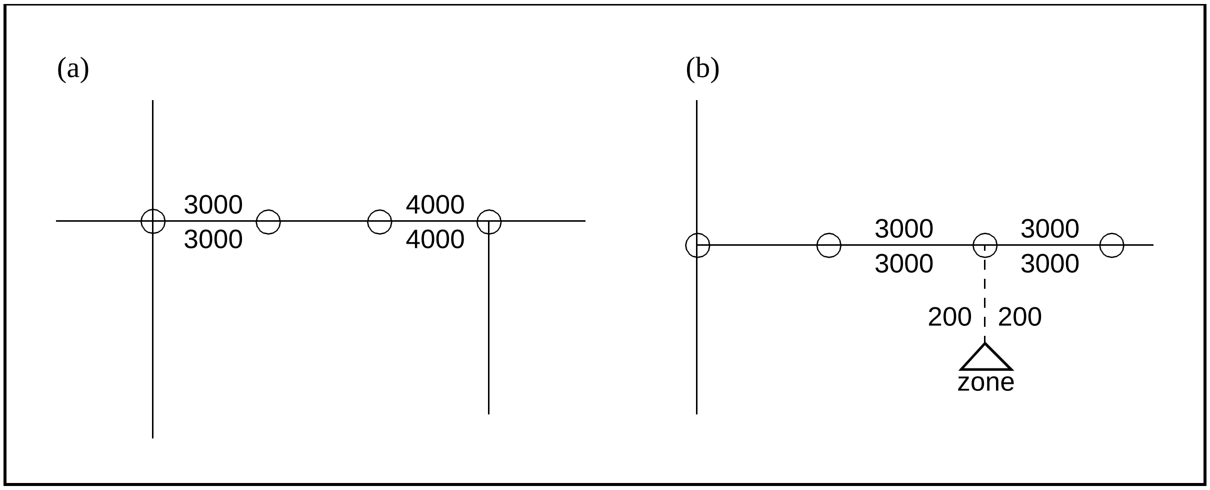

Figure 1: Inconsistent counts

The network must contain *some* counts. The networks to which this process has been applied thus far have contained counts on 7-8% of their links. It is believed that the process will work with as little as 4% count coverage, but obviously, the more counts, the better. Counts should be directional, for ease of processing. If daily non-directional counts are available, they should be divided in half and posted on each side of the road.

It is extremely important that the count data be internally consistent and logical. Situations such as those shown in Figures 1a and 1b must be avoided. This is because regardless of the accuracy of the count, it is impossible for assigned volumes to *ever* match the counts shown in these figures. In such cases, counts could be averaged, or one count could be removed in favor of the other. Inconsistent counts will distort the process, leading to unreliable results. This is true for *any* assignment validation process. (Actually, the situation in Figure 1b is technically possible, but extremely unlikely.)

Any assignment procedure can be used: equilibrium, incremental (CATS), all-or-nothing, stochastic, etc. The MINUTP ASSIGN program can accommodate a variety of procedures. As developed thus far, the adaptable assignment process assumes that the assignment procedure is fixed and that only the trip table varies. The output of Step 1 is a loaded network which contains both assigned volumes and counts.

Step 2: Network Calculations

MINUTP provides an all-purpose network calculator called NETMRG. In this step, NETMRG is used for three things:

2a) Calculate Assignment Accuracy

The square of the error (count - assigned)^2 is calculated for each link with a count and summed for the network. If the number of links with a count is known, the total squared error can be used to manually calculate the percent root-mean-square error (%RMSE), which is widely used to measure assignment accuracy. (The most recent version of NETMRG calculates the RMSE automatically.) The %RMSE is calculated as follows:

$$\%RMSE = 100 \times \frac{\sqrt{\frac{\sum (count - assignment)^2}{n}}}{\frac{\sum count}{n}}$$

where n = number of links with a non-zero count (in some formulations, the n term inside the square root is replaced with n-1)

<u>2b) Compute "Assignment Criteria"</u>
For reasons that are explained below, two new network variables are calculated for each link: the count multiplied by a "scaling factor" (a fraction) and the assigned volume multiplied by the same fraction (computed only for links with a non-zero count). A typical value for this scaling factor is 0.1.

<u>2c) Check Major Links</u>
The count, assigned volume, and percent error for major links are calculated and listed. "Major" is usually defined as links above a certain count volume or links of a certain facility type, but any similar criterion can be used.

The result of Step 2 is another loaded network, with two new variables, plus a listing file that can be used to check the procedure's progress.

Step 3: Skim Assignment Criteria

This is the heart of the procedure. Almost all software packages can "skim" a network's time and distance (i.e., compute minimum paths and sum the time and distance along those paths for each origin-destination (O-D) pair). MINUTP's PTHBLD program can skim almost *any* variable and that feature is used here to skim the two assignment criteria: the factored count and the factored assignment. The only limitation (in MINUTP) is that for any O-D pair, the total skimmed count and the total skimmed assigned volume must each be 32,767 or less. This is why the assignment criteria are computed in Step 2b as a fraction of the original count and assigned volume.

The result of this step is two matrices: one representing a fraction of the total counted volume on the minimum path for each O-D pair and another representing the same fraction of the assigned volume on counted links on the minimum path for each O-D pair.

Step 4: Trip Table Adjustment

The final step uses MINUTP's MATRIX program to calculate an adjustment factor for each O-D pair with non-zero trips (this process does not insert values into zero trip cells). The ratio of the two matrices from Step 3 is: total factored count/total factored assignment. This ratio indicates the direction and magnitude of the "error" for each O-D pair.

It appeared desirable to provide for some damping of the calculation so as to prevent undesirable oscillation of the resulting estimates. Thus, a "sensitivity factor" is introduced, to dampen the adjustment, resulting in the following equation for the adjustment factor:

$$adjustment\ factor_{O-D} = \left(\frac{\sum factored\ count_{O-D}}{\sum factored\ assignment_{O-D}} \right)^{SF}$$

where SF = sensitivity factor

Thus far, reasonable results have been obtained with a sensitivity factor of 0.50. Higher values will result in faster convergence, but at the possible expense of undue trip table distortion. The "optimal" value of this parameter, if one exists, must await further research.

Once the adjustment factor is known, the new trips are calculated as:

$$\text{new trips}_{O\text{-}D} = \text{adjustment factor}_{O\text{-}D} * \text{old trips}_{O\text{-}D}$$

In this calculation, extra care must be taken to ensure the integrity of the trip table cell values. Bucket rounding or some other technique should be used to ensure that the resulting integer trip values reflect the intended calculation as accurately as possible. Finally, the delta trip matrix is calculated as:

$$\text{delta trips}_{O\text{-}D} = \text{new trips}_{O\text{-}D} - \text{old trips}_{O\text{-}D}$$

MINUTP is capable of handling and storing negative trip table entries, although special care must be used.

These four steps constitute one iteration of the procedure. It is necessary to repeat Steps 1 and 2a to see how well the adjusted trip table assigns. In practice, the entire procedure is applied 10-20 times, with the adjusted trip table from each iteration used as the input for the next iteration. Examination of the %RMSE value that is derived from Step 2a provides indicates how well the process is working.

One feature which can be added to the basic process is a FRATAR step after, say, every fifth iteration. The purpose of this is to force the trip ends of the adjusted trip table to be equal to some desired values, usually the original trip ends. In some cases, the original trip ends are deemed to be acceptable and the analyst would want the process to change only the individual cell values, while maintaining the original row and column totals. Frataring the adjusted trip table back to the original trip ends accomplishes this (approximately). By applying the FRATAR process after every fifth iteration, the analyst ensures that the adjusted trip table never strays too far from the original. It should be clear, however, that the FRATAR process disturbs the adjustments made by this procedure and that a less accurate assignment will result. In some instances, this may be an acceptable trade-off.

Another optional feature is that it is possible to adjust the trip table so that the assignment is extremely accurate for a select set of links. In some cases, the analyst may need for the assignments to match the counts on a small set of links to a very high degree of accuracy. This can be accomplished by adding a dummy variable to the network, named something like PRIORITY. The selected links are given a PRIORITY of 1 and all other links are given a PRIORITY of zero. Then, the equations for the assignment criteria become:

$$\text{factored count} = \text{original count} * 0.1 * \text{PRIORITY}$$

$$\text{factored assigned volume} = \text{original assigned volume} * 0.1 * \text{PRIORITY}$$

Essentially, this is equivalent to posting counts only on those links in the selected set. If there are fewer than, say, ten links in the selected set, applying adaptable assignment in this manner will practically guarantee that the assigned volumes will match the counts on those links. This process has also proven useful in trying to match counts that are very different in magnitude (say, daily traffic of 1,000 and 50,000 on nearby links).

It must be recognized that this process can modify the starting trip table in undesirable ways. Thus, the analyst must carefully examine the adjusted trip table. It is necessary to analyze the trip length distributions of the original and revised tables as well as district-to-district trip patterns, to be assured that the adjustments are appropriate.

Forecasting

The above discussion describes how to obtain an adjusted trip table, or alternatively, a delta trip table. The more interesting question is what to do with that table. Some analysts believe that it is appropriate to simply carry the delta trip table along into forecasting. For example, the analyst would use some procedure to obtain a future year trip table and would then add the delta trip table to it to obtain the final future trips.

Other analysts feel it is appropriate to develop a base year "ratio" table, in which the cells represent the ratio of the final adjusted trip table to the original trip table, factored by 1000 to represent integer values (most packages store matrix values as integers, so a ratio of 2.145 would need to be stored as 2145, with an understood divisor of 1000). The original future year table would be factored by this ratio table to obtain the final future trips.

While either of these approaches might be acceptable in some studies, it is unclear if they would be found acceptable by a "best practices" or peer review. If resources and circumstances permit, it seems more appropriate to use the delta trip table to modify the procedure used to obtain the original trip table. This could involve, for example, changes to the trip generation rates, identification of special generator zones, use of K factors in distribution, and mode share adjustments. In effect, the delta trip values would be integrated back into the model itself.

Sample Application

The adaptable assignment procedure has been used in Princeton, NJ, Reading, PA, the US 1 corridor in central New Jersey, and West Windsor Township, NJ. The West Windsor case is the best documented and is described here. West Windsor is a small town located in the heavily congested US 1 corridor north of Princeton, close to the geographic center of the state. The network consists of 275 zones and 1,600 links. The trip table represents 1993 peak hour vehicle trips and was synthesized from a combination of approximate trip rates, borrowed F factors, and cordon counts. About 7% of the links had posted counts. The following parameters were used:

- scaling factor = 0.1
- sensitivity factor = 0.50
- iterations = 20
- no Fratاring of trip ends

Table 1: West Windsor results

	AM	PM
Total Count	89,152	118,076
Initial Total Assigned Volume	103,687	147,325
Final Total Assigned Volume	89,198	117,521
Total Volume Error	+0.05%	-0.47%
Initial Trips	20,324	23,995
Final Trips	19,264	21,674
Total Delta	-1,060	-2,321
Pct. Difference	-5.2%	-9.7%
Initial %RMSE	42.7%	48.2%
Final %RMSE	21.9%	16.2%

Table 1 shows the AM and PM results and Figure 2 shows the PM change in %RMSE by iteration. As these results show, the improvement in assignment accuracy is substantial. This run

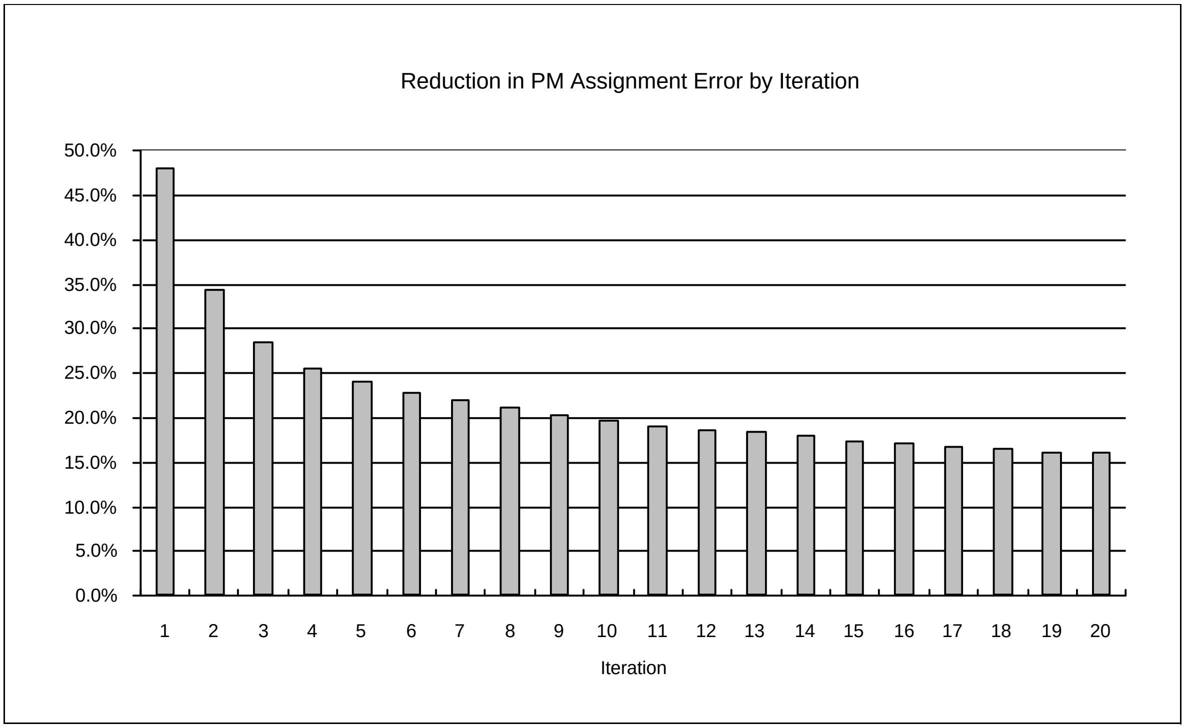

Figure 2: Reduction in p.m. assignment error by iteration

could probably have been stopped after 10 iterations, since the remaining improvement is fairly small. In fact, the overall improvement in accuracy is probably better than what can generally be expected, because the study area is a fairly small network. As Table 1 shows, the changes to the original trip table are fairly minor, in total.

Conclusions

A new procedure has been developed to adjust a trip table to better match available traffic counts. This "adaptable assignment" procedure has the advantages of being simpler and more accessible to users than other techniques. Although the procedure was developed using MINUTP, it might be possible to apply it using other software packages, but in any case, no expensive software or compiled programs are needed.

This procedure has been applied in a number of real-world studies and has been shown to produce substantial improvements in assignment accuracy without unduly distorting the original trip table. It is believed that by simplifying the process of trip table adjustment, adaptable assignment will enable more transportation planners to use and understand this tool.

Acknowledgments

The adaptable assignment procedure was developed by the author with the assistance and advice of Gary Davies of Garmen Associates. Most of the case studies mentioned here were studies conducted by Garmen. The opinions expressed are those of the author, who bears sole responsibility for the content of this paper.

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Methods for Estimating Non-Motorized Travel to Meet the Needs of MIS

Mark Roskin and Victor Siaurusaitis, COMSIS Corporation

Abstract

Estimation of non-motorized pedestrian and bicycle trips has never been possible using traditional travel demand forecasting procedures. Obvious problems related to conceptual network representation for non- motorized modes, and the difficulty of collecting observed data to calibrate these modes has hindered this process. This paper details several methods that have been used in conjunction with travel demand model outputs to estimate non-motorized trips. Several methods have been identified as developed from project work in Salt Lake City-Utah, Davis-California, and Hampton Roads-Virginia.

The first method is based on the development of "friendliness" indices that rank each area in the region based on criteria related to accommodating pedestrian and bicycle travel. This ranking is then used in conjunction with a look-up table as developed from local and national data that calculates the percentage of trips that are non-motorized by purposed. These percentages are then used on the travel demand model estimates to split out non-motorized trips. The second method uses information from the travel demand model for zone-to- zone travel time and distance to determine non-motorized trips based upon some linear (or non-linear) function. This method also relies on observed data to determine these functions. A third method looks at the possibility of actually estimating non-motorized trips using a traditional travel demand model mode choice routine. Davis, California provides a unique laboratory for the evaluation of these methods because of the treatment of the bicycle mode on the city streets. Using Davis as a case study, this method is detailed for the possibilities of making a true mode split estimate of non-motorized trips.

Modeling Non-Motorized Travel in the Philadelphia Area

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Abstract

Most U.S. urban area travel demand model systems focus only on travel by highway and transit modes. Metropolitan planning organizations in the U.S. have recently begun to analyze non-motorized travel, which includes the walk and bicycle modes. Recent interest in reducing congestion and improving air quality, due in large part to federal legislation, and a recognition that non-motorized travel often serves as a substitute for motorized modes have stimulated interest in the analysis of non-motorized modes.

The Delaware Valley Regional Planning Commission, the MPO for the Philadelphia area, has studied ways of incorporating non-motorized travel in to their model system. The experience of other U.S. urban areas has been that non-motorized travel can be incorporated into model systems using modern household travel or activity surveys, which collect detailed information about non-motorized trips. However, the Delaware Valley last conducted a household survey nearly a decade ago, before it was common practice to include non- motorized trips in such surveys.

The procedures to incorporate non-motorized travel into the DVRPC model system include revised trip generation models to include both motorized and non-motorized trips and a binary logit mode choice model, applied to trip ends for each zone, which separates motorized form non-motorized trips. The motorized trips are then used in the trip distribution, (motorized) mode choice, and trip assignment models. Other than a small sample of walk to work trips in the DVRPC household survey, there was no local data on nonmotorized travel from which models could be estimated. Therefore, the trip generation and mode choice models were developed using a variety of alternate data sources, including the 1990 Census Transportation Planning Package and more recent household surveys from other U.S. urban areas which asked about walk and bicycle trips.

Pedestrian environment variables were developed and used in the mode choice models to reflect local differences in pedestrian friendliness through out the region. These zone level variables were developed by transportation professionals familiar with the region, including DVRPC staff. The pedestrian environment variable is a subjective index similar to what is used in a few other urban areas and considers sidewalk availability, ease of street crossings, and building setbacks.

Making Do with Less: Calibrating a True Travel Demand Model Without Traditional Survey Data

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Abstract

For many small and medium-sized cities, funding a full Home-Interview survey, with costs as high as $100 per household, is not feasible. Traditionally, such a survey has provided the basic foundation for developing a truly useful travel demand model. Without it, model development has been handicapped by the lack of such behavioral, disaggregate data. This problem was faced recently in Jamestown, North Dakota, for which it was necessary to develop a travel demand model for small (population 16,600) city, with no recent origin- destination data.

The technique relied on the fact that a sufficiently robust set of simple traffic counts contain a great deal of travel behavior information implicitly. Using a set of consistent, concurrently-taken counts, external travel behavior from an older study, and a detailed zone system, a technique has been developed which can produce a fully-specified, classical travel demand model. Not only can this model be calibrated quite closely to existing counts, but it can be used as a forecast tool, requiring only socioeconomic and network data. In other words, the traffic count data was tied not only to a current origin-destination trip table, but to distribution parameters, time of day parameters, and trip generation rates at the zone level. The procedure involves an extended application of the “O-D from traffic count” technique (which is implemented through a macro in EMME/2), essentially working the four-step modeling process in reverse. Through iterations of the model, proper generation and distribution parameters can be developed, which, when finished, reliably reflect actual conditions.

This technique can be a very cost-effective way for small and medium-sized cities to obtain a travel demand modeling capability which is not simply a product of “borrowed” parameters from another area, but is indeed calibrated to local, observed conditions.

The transportation planning needs of small and medium-sized cities have become more sophisticated, as they attempt to address the needs of the community. The difficulty has been increased due to more stringent planning requirements imposed by the 1991 ISTEA (Intermodal Surface Transportation Efficiency Act) and by the lack of sufficient funding, which forces difficult choices, and requires clear justification of future plans. These demands often require transportation plans to be developed in a more analytical way, and a key element to these plans is often a travel demand forecasting model. While major metropolitan areas almost always have some type of model, smaller areas may have only old, or special-purpose models, or none at all. For these communities, the choices are:

- Proceed without a model, or use the existing model, which may not be adequate
- Develop a new travel demand model

The first choice, for reasons mentioned above, may lead to an inadequate or even misleading plan. The second option, however, can be expensive.

A truly useful model has traditionally required data collected from a comprehensive origin-destination survey, or set of surveys. Home interview surveys, which are typically used to collect this data, are expensive, ranging from $50 to $100 per household. For even a 1 percent sample, this can quickly become a major expense for even a small city. Keep in mind that, even for a small city, a minimum sample size is probably at least 1200-1600 households. Additional cost will be incurred processing the survey results, including geocoding, survey record cleaning, trip chaining, factoring and creating a calibration data base.

In addition to the cost, gaining approval from politically-appointed councils for survey funding is often difficult, since the task is several steps removed from showing direct benefits to the community.

For these reasons, travel demand forecast models have often been developed without contemporary origin- destination data, leaving the resulting models insufficient for their analytical tasks, or at least open to criticism and attacks on credibility of results.

To address this problem, a technique has been developed which seeks to strike a compromise between depending upon expensive and difficult to obtain O-D data, and model development without reference to local travel behavior data. This paper describes this technique, and the results of an application in Jamestown, ND.

Background

Barton-Aschman Associates was retained by the City of Jamestown, North Dakota to develop a Land Use and Transportation Plan for the City and surrounding area. The previous plan had been developed in 1970, and the lack of an updated plan was hindering the project development process for any major transportation infrastructure improvement. State and Federal funding for such improvements required an up-to-date plan for the area. As a part of this plan, a travel demand forecast model was prepared, and submitted to the North Dakota Department of Transportation planning office for review and approval. No previous travel demand model had been developed.

Jamestown, North Dakota is a community of about 16,600 persons, with an additional 5,600 persons in the surrounding county (Stutsman County). The city lies just off of I-94, about halfway between Bismarck on the west, and Fargo on the east, approximately 95 miles from each city. North/South access is provided by US281. The economy is agriculturally-based, with some light industry, bulk food and cattle processing. Jamestown is the home of a buffalo museum, State Hospital, a school for children with physical disabilities, and a small 4-year liberal arts college--Jamestown College. Bisecting the community is the main line of the Burlington Northern Railway, which primarily hauls coal from mines to the west, to power plants in Minnesota and the port of Duluth/Superior. It is a heavily used line (about 27 trains/day), which passes through the heart of the downtown. One grade separated crossing exists, along with 6 at-grade intersections involving local streets. Major transportation issues center on reducing train/vehicle interaction, and reducing the North/South truck traffic through the downtown, which currently has no other route option.

Over the past 10 years, Jamestown has remained static in growth. For the purposes of the plan, however, significant growth was assumed, to a population of 20,600. In recent years, employment has increased, without causing a significant increase in population. Future growth in employment, it is believed, will finally begin to expand the population and household base.

In order to adequately address the transportation impacts of anticipated growth, and of proposed major transportation improvements, including a north/south bypass, a travel demand model was necessary. In addition, the North Dakota Department of Transportation required a model-based plan. However, as mentioned above, no previous model existed. In addition, only a 1973 external travel survey was available, providing only the most general information on trip origins and destinations. Resources simply did not exist for conducting a home interview survey. However, some information was available, including

- A very comprehensive, contemporary and consistently-obtained set of traffic counts for all major areas of the city.
- A very complete, and comprehensive inventory of households, and employment, with locational information. The households were classified by density, and employment was divided into retail and non-retail.
- Summary information regarding work trips for the county and city from the 1990 Census Transportation Planning Package (CTPP).
- Good information regarding roadway widths, speed limits, signal locations, and general roadway network information within the City.

The availability of these data, and the quality of the data, supported the approach of creating a relatively simple, traditional travel demand model for the City. The model would have the advantage of containing parameters based on local travel behavior, rather than relying upon “borrowed” model coefficients, as is often done. The model could be calibrated not just in the sense that it replicated traffic counts, but to some degree also reflected community trip generation, distribution and trip length characteristics.

The key to this was the excellent count information available. The North Dakota Department of Transportation (NDDOT) conducted a set of tube counts in the fall of 1994 at over 150 locations in the city. These were then seasonally adjusted, and published on a map. All counts were taken within a few weeks of one another. Peak hour turning movement counts were also taken at selected intersections. A set of counts such as this may be thought of as a “snapshot” of the community’s vehicular travel behavior. While any individual count shows only volume on a street at one location, taken together, the counts are indicative of all travellers’ trip-making behaviors. Implicit in the data set is the trip generation, and distribution characteristics needed for a traditional travel demand model. The information on the socioeconomic data (households and employment) was also available in detail. Combined with the other data sources, we began the model development process knowing much about the beginning and end of the model, and something about how to get between them in terms of traveller behavior--all with locally-based data.

The real task, therefore, was how to extract the specific travel behavior information required for the model. This was done first by estimating a simple, generic model, using typical rates for trip generation, distribution, and other key parameters such as external trip percents. Executing this model provided an initial vehicle trip table, which can then be used in the second step. The initial trip table is adjusted to correspond with the set of observed counts in a process commonly known as O/D by traffic counts. Though not a unique solution, this adjusted trip table represents a most likely outcome, given the initial trip table. Next, the third step is to run the model “backwards” to obtain implied parameters regarding trip distribution (F and K factors) and trip generation rates. Finally, the model is run forward again, using the new parameters, to create a new seed matrix for adjustment. the third and fourth steps are repeated until no further improvement can be obtained. This is the overall process. The rest of this paper will discuss several key details of the process, the results for Jamestown, and conclusions regarding the process.

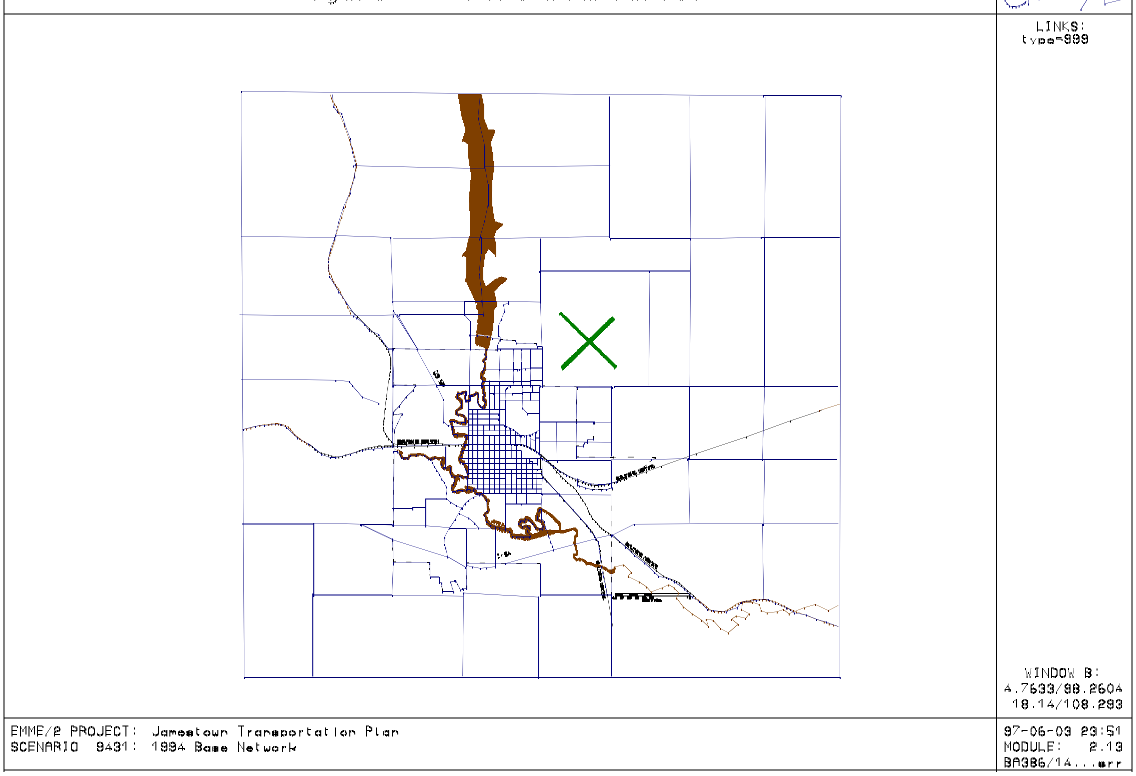
Initial Model Development

The first task was to develop an initial model, however approximate, which would ultimately supply the first trip table for the O/D by traffic count adjustment. The supply side of this model is represented by the network and zone system. A very detailed zone system was developed, which included 274 zones. In the core of the city, virtually every block was itself a zone, and almost all streets were explicitly coded. Eleven external zones were used for identifying major access locations. The modeled area consisted of roughly a square 8 miles by 8 miles in dimension. The detail of the network was necessary to support the number of counts. A detailed zone system would also enhance the trip table adjustment process, by providing the greatest level of specificity in terms of origin and destination locations. The zone system, and modeled area, are shown in Figure 1.

Once the network had been developed, and the socioeconomic data assigned to the proper zones, the demand side of the forecast model was developed, starting with the trip generation model.

Though many options exist for the functional form of the trip generation model, a linear model form was selected, based on experience in smaller cities, and in keeping with similar models developed in Grand Forks, Fargo and Bismarck. Three trip purposes were modeled, including Home-Based Work (HBW), Home-Based Other (HBO) and Non Home Based (NHB). The variables selected for the trip production model were single family detached households, households in groups of 2 to 9, and households in high-density situations (greater than 10). These groupings

Figure 1: Zone Boundaries



probably serve, in part, as a surrogate for wealth in small cities such as Jamestown. The trip attraction equations used total employment for HBW attractions. Both HBO and NHB attraction equations used all three household types, plus retail and non-retail employment. The initial coefficients were selected based on standard practice and typical generation rates in other North Dakota cities. In all cases, the trip generation equations were assumed to estimate daily vehicle trips.

Once the trip generation equations were defined, external trips were estimated by taking a percentage of each zone's productions and attractions. At the external stations, existing counts were used as a starting point. They were divided by purpose, and split into productions and attractions corresponding to control totals. These totals were derived by examining current count volumes, and the results of a 1970 survey, which was used to estimate through trip percentages. Standard values for characteristics of external trips, from NCHRP 1871 was also used. Table 1 summarizes some of the key parameters used in the initial model, which were held constant throughout this process.

Table 1: Key model parameters held constant in calibration process

Parameter		Value
Work Trips Per Employee		1.7
External Trip Purpose Shares	HBW	15%
	HBO	70%
	NHB	15%
Auto Occupancy	HBW	1.20 Persons/Vehicle
	HBO	1.32 Person/Vehicle
	NHB	1.24 Person/Vehicle
Exponent for Friction Factors	HBW	1.99
	HBO	2.40
	NHB	2.35

Finally, a set of special generators were identified. These included the Airport, Shopping Centers, the State Hospital, and Jamestown College. Trip generation for special generators was based on standard rates from the ITE Trip Generation Manual, and were not adjusted during the calibration process.

Trip distribution was next. For external trips, a fratar process was used to distribute trips to external stations. The initial distribution was based upon previous O-D survey percentages. Internal trip distribution was by type, and used a gravity model formulation. Friction factors were calculated by the following formula:

$$F_{ij} = C \times \frac{1}{t^n}$$

Where F_{ij} is the friction factor between zones i and j. C is a normalizing factor, t is the travel time, and n is a parameter which varies by trip purpose (the latter is listed in Table 1).

The trips were summed, and transformed into origin/destination format from production/attraction format. The trip table was assigned for reference purposes. However, the primary use of the trip table was to use as a seed matrix for the O/D by traffic count adjustment.

Adjustment of O/D trips

In this step, the information implicitly contained in the observed set of traffic counts is used to update the initial trip table. A total of 568 one-way count locations were used as a basis for the comparison. These were compiled from the counts taken as a part of this study (mid block and intersection) and historic count data. They were expressed as average weekday traffic volumes, adjusted for seasonal and day-of-week variations by the North Dakota DOT.

The particular application used for this study was developed by Mr. Heinz Spiess, of INRO Consultants, and is documented in a May 1990 CRT publication[1]. The process is based on minimizing an objective function. This function is a measure of the difference between observed and estimated volumes on the links. A gradient method is used to find this minimum, which in turn corresponds to a new trip table. Note that the nature of the problem means that there are a very large, if not infinite, number of "best" solutions, mathematically. One common problem in O/D trip table estimation is that of degeneracy--that is, as the search for a minimum objective function progresses, the new trip table becomes increasingly unlike the original matrix. In modeling terms, this is undesirable, since much valuable information may be lost if the final, adjusted trip table is quite different from the original. An advantage of the gradient method, used with optimum step lengths, is that the final trip table will not be radically different from the original. This will ensure that measures of travel behavior such as average trip time, vehicle-miles and vehicle-hours of travel, and trip generation rates, will not be radically changed because of the O/D adjustment process. In addition, zonal interchanges with no trips remained at zero in this process, and an additional constraint was placed on the process which limited any zone-to-zone trip adjustment to between 50 percent and 150 percent of the initial value. In this way, the total number of trips did not grow excessively, which was otherwise the case.

It is important to note that for the O/D adjustment to work properly, and produce reasonable results, several items required special attention, including:

- The counts must correctly entered, and consistent among themselves. Erroneous or unreasonable counts will distort the O/D trip table adjustments. Inconsistent counts will also distort the trip table adjustments, and lead to mismatches (observed vs. estimated) even among valid counts.
- The network must be accurately represented. Obviously, the observed counts reflect travel behavior on the actual street and highway network. To the extent that the modeled network does not reflect the travel times actually experienced, at least in relative terms, the O/D adjustment will be unable to properly develop a realistic trip table.
- The location of the count links should ideally be placed to capture all trips in the network. Counts near major generators may lead to distortions. Also, any count which might have high intra-zonal trips should be avoided, since these trips will not be adjusted or even accounted for in the assignment process.
- The requirement to minimize intra-zonal trips in the previous items leads to and advantage in creating a very detailed, small-zone network, which we did in the Jamestown model.

In the actual application of this gradient approach, the process was executed through the use of a macro applied within the EMME/2 (c) transportation planning software package. The nature of the optimization problem means that the process is iterative, as the minimum of the objective function is searched. After examining the convergence characteristics of the process, ten iterations were selected. Further iterations showed very little improvement in observed vs. estimated comparisons.

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1. Spiess, Heinz. "A gradient approach for the O-D matrix adjustment problem." Publication #693, Center for Research on Transportation, Université de Montréal, May 1990.

Reversing the Model:

Once the trip table had been adjusted, considerable improvement was evident in the fit between observed and modeled link volumes. The next step was to develop a model which obtained this target trip table. In order to do this, the model was reversed, in the following way

Step 1: The resulting daily trip table first must be split into the HBW, HBO, and NHB trip purposes. This was done by factoring the total daily trip table by the previous splits. Note that this implicitly assumed that the O/D adjustments applied equally to all purposes, at least in terms of distributional factors.

Step 2: The purpose trip tables were then multiplied by purposes-specific occupancy factors, which provides person-trip tables. Though still in O/D format, these trip tables may then be used to adjust the trip distribution for internal trips. Internal/External and through trips were separated into separate matrices, and were used as seed matrices for the fratar-ing process in the next iteration.

Step 3: Calculate new K-factors by the following formulas:

$$\text{Kfact Adj} = \frac{\text{Obs Trips}}{\text{Friction Factor}}$$

$$\text{Kfact Adj'} = \frac{\text{Kfact Adj}}{\left(\frac{\sum \text{Kfact Adj}}{n}\right)}$$

where:

Kfact Adj = Adjustment Factor to apply to previous iteration Kfactors (by zonal interchange)
Obs Trips = Observed Trips by purpose
Friction Factor = Friction Factors, based on travel time, and specific to purpose

Next, the Kfactor adjustment factor is “normalized” by dividing each cell value by the unweighted average, as shown in equation 3, where:

Kfact Adj’ = “normalized” Kfactor Adjustment Factor
n = Number of cell values (274x274 = 75,976)

Finally, the new Kfactors are estimated by multiplying the adjustment factor by the previous K- factors (initial Kfactors were set to 1.0 for all interchanges). This is shown in equation 4.

$$Kfact_{i+1} = Kfact_i \times KfactAdj$$

where:

$Kfact_{i+1}$ = New Kfactor, for iteration *i+1*
$Kfact_i$ = Previous iteration Kfactor (iteration *i*)

As an option, the Kfactors may be aggregated to district interchanges. This will tend to even out extreme Kfactor values.

Step 4: The observed trip tables, by purpose, were summed by row and column, which represented the total person-trips in and out of each zone on an origin/destination basis. These totals were then split into productions and attractions, using the P&A proportions from the previous model iteration trip generation results. This approach assumes that any changes resulting from the O/D adjustment apply to both production and attraction land uses equally. The result of this step was a set of observed productions and attractions for each zone, in terms of person-trips.

Step 5: The trip generation equations were re-estimated, using the new "observed" productions and attraction totals. This was done using a standard linear regression technique.

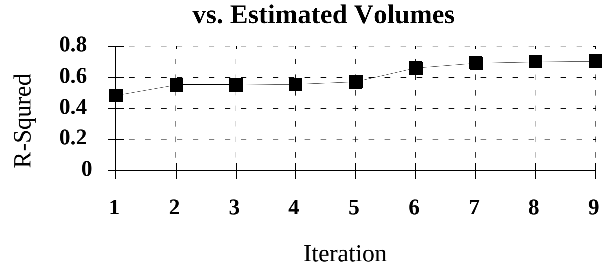
At the end of step 5, a new set of trip generation equations, new K-factors, and new seed matrices for Externally-based travel were ready. The model was then applied "forwards" to estimate a new daily vehicle trip table. At this point, the O/D by traffic count adjustment was applied and the process of re-estimating the model was started again. This process was continued until no further improvement could be obtained in terms of the observed vs. estimated count comparison.

Results

The success of the procedure may be measured by several factors. Most importantly, we should expect that the process would improve the model performance in terms of it's ability to replicate observed volumes. The results showed this to be the case. Initially, the modeled volumes compared with the observed counts with an r-squared value of 0.553. This eventually improved to an r-squared of 0.716, a 30 percent increase in r-squared. Figure 2 shows the progression of r-squared values by iteration. A total of 12 iterations were used before it was determined that no further improvement could be made. Eventually, the model was able to meet the NDDOT requirements for model performance criteria.

Figure 2

R-Squared Value for Observed vs. Estimated Volumes



The final comparison plot showing observed vs. estimated link volumes, and the NDDOT criteria, are shown in Figure 3. The criteria permitted a percent deviation from observed, based on the magnitude of the observed volume. Ninety percent of the count locations must meet this criteria. In this case, those count locations not meeting the criteria were not located systematically, and were not key segments. The model also resulted in reasonable trip generation equations, as shown below:

HBWP = 3.272*SFDU + 2.591*MFDU + 2.976*HDDU
HBOP = 9.728*SFDU + 7.708*MFDU + 9.209*HDDU
NHBP = 2.052*SFDU + 6.216*MFDU + 1.035*HDDU

HBWA = 1.7*EMP
HBOA = 4.451*SFDU + 2.788*MFDU + 3.037*HDDU + 25.958*RET + 0.604*NRET
NHBA = 1.039*SFDU + 0.732*MFDU + 0.835*HDDU + 2.678*RET + 2.364*NRET

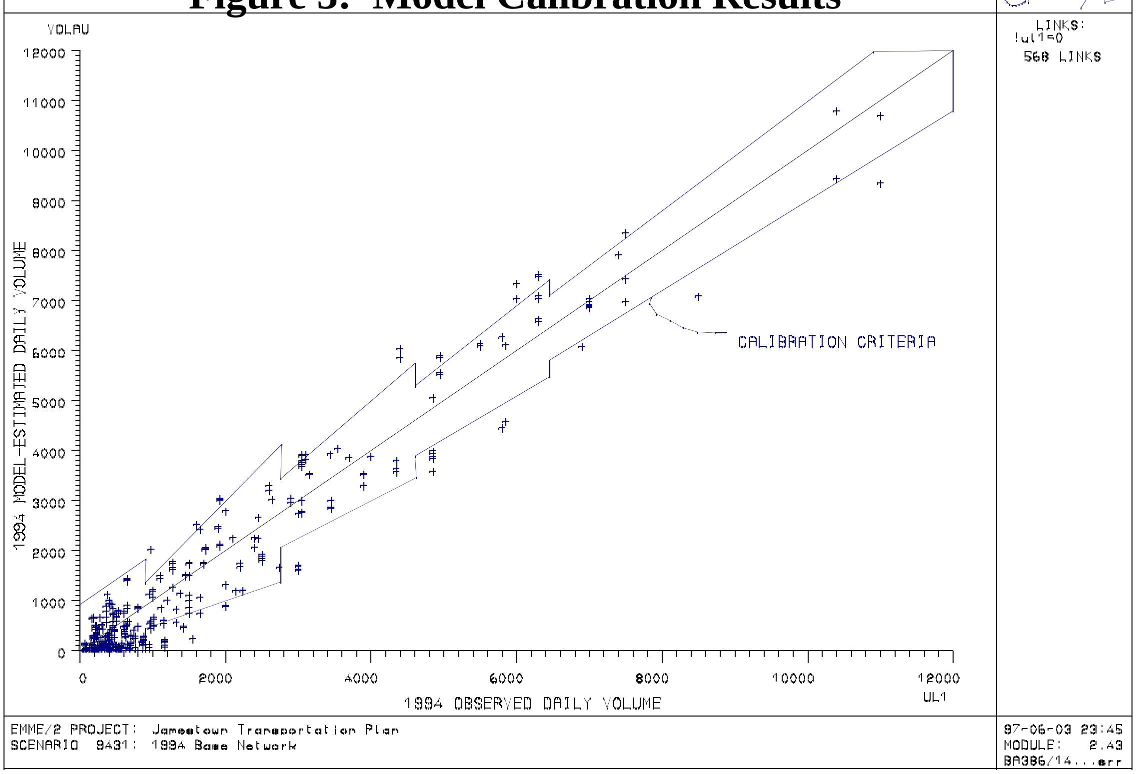
where:

HBWP = Home-Based Work Person-Trip Productions
HBOP = Home-Based Other Person-Trip Productions
NHBP = Non-Home Based Person-Trip Productions
HBWA = Home-Based Work Person-Trip Attractions
HBOA = Home-Based Other Person-Trip Attractions
NHBA = Non-Home Based Person-Trip Attractions
SFDU = Number of Single-Family Detached Homes
MFDU = Number of Households in groups of 2-10
HDDU = Number of Households in groups of 10 or more
EMP = Number of Employees
RET = Number of Retail Employees
NRET = Number of Non-Retail Employees

The relatively higher HBW and HBO production rates for HDDU may have resulted from the relatively few (18) zones in which these occurred, which provided a small observed data set for calibration.

The trip generation equations imply about 15 one-way trips per person per household. With an average occupancy of 2.3 persons per household, the model assumes about 6.5 one-way trips per

Figure 3: Model Calibration Results



person per day.

Screenline comparisons were very good. Three screenlines were used, following major east-west and North/south barriers within the city. No screenline deviated more than 1 percent, and the average deviation from observed counts was 0.3 percent low. Screenline comparisons were refined by the application of special K-factor adjustments.

Areas for Improvement

While the procedure resulted in a workable model, the process revealed several areas which could be improved. These included:

1. Estimation of new trip generation parameters. An alternative method might have been to add a unique zonal constant to each zone's trip generation equations. This would have preserved the original parameters yet more explicitly represented the variation in zonal trip characteristics. This would require, however, more confidence in the original parameters than was available for Jamestown. This type of methodology was applied in subsequent model estimation projects with some success.
2. Use of additional O-D information. Though not available for Jamestown, some additional origin-destination information is often available in the form of the Census CTPP data, previous model output or previous survey information. Since the trip table adjustment does not produce a unique result, it is important to use an initial matrix which is as accurate as possible.
3. Identification of special generators. In Jamestown, a small set of special generators were preselected. However, the calibration process may reveal other zones which do not fit the standard trip generation equations. The land use in these zones should be inspected to identify unusual land uses, which could be treated as special generators.
4. Automation of iterative calibration process. The steps of trip table adjustment, re-estimation of distribution parameters, re-estimation of trip generation parameters, model execution, and count comparison are essentially straightforward computational steps. These can and should be automated, to speed up the calibration process. Reporting these results in summary fashion allows the modeler to review progress and check for errors.

Conclusions

The process described here proved successful, in that it produced a reliable, conventional travel demand model for a community at a relatively low cost, and without the need for detailed origin-destination survey data. It was greatly aided by the OD trip table adjustment routine, an application of the EMME/2 software. The process does require a detailed zone and network system, with accurate travel times. Land use assumptions must be similarly detailed, with proper identification of special generators so that the basis for trip generation can be accurate. While some model assumptions, such as the trip generation variables, functional form, and friction factors, must be set exogenously, most of the actual model parameters were estimated based on the detailed traffic count database. This model estimation process may be particularly useful for communities with not history of travel demand models, and which lack resources to develop a detailed origin-destination trip database.

Quantifying Special Generator Ridership in Transit Analyses

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Abstract

In major investment analyses and transit corridor studies, the impact of conventions, sporting matches, and other special events on transit ridership is often of interest. In many locations, it is hypothesized that additional ridership to and from such sites can provide substantial additional revenue for the transit system at little additional cost. In addition, the transit system might be used to relieve traffic congestion around the venues used for these special events.

While some cities have used rigorous analyses to account for the non-home-based transit ridership that might be induced by fixed guideway facilities, the impact of special generators on regular or specially scheduled transit service is typically analyzed using ad hoc procedures and "rules of thumb." This paper describes an analysis process, developed as part of the "Gold Line" commuter rail study in Denver, Colorado, that introduces uniform procedures for analyzing the impact of regular and periodic special generators on transit services in the Denver area. These procedures can be readily generalized for use in other cities.

Local travel to sporting events, festivals and other special community events can contribute significantly to transit ridership and revenues. Seldom, however, is transit ridership from special events formally included in the four-step travel demand modeling process used for major investment studies. Typically, the evaluation level is little more than a comment that such functions would add to the transit ridership levels for the alternatives tested.

In 1995, the six-county Denver metropolitan Regional Transportation District (RTD) recognized the need to address this weakness in transit investment studies and funded a study to develop a consistent approach to analyzing the additional transit ridership that can be expected from "special generators."

The focus of the special generator assessment was a proposal for commuter rail service on the "Gold Line" — a freight rail corridor between downtown Denver and Golden, Colorado. In previous studies, RTD had examined the viability of this corridor for peak period only commuter rail service. Projected demand, however, was not sufficiently high (or cost effective) for inclusion in the Denver area's regional transportation plan. Recent new developments in the corridor including sporting venues and an amusement park have revived interest in the Gold Line.

The new developments which could potentially contribute to Gold Line ridership are of a special event variety, many of which occur during off-peak periods or weekends. RTD was asked to reconsider the Gold Line operating assumptions and re-estimate future ridership explicitly considering this off-peak, special generator ridership. The use of a traditional modeling approach, in which average daily trips and transit ridership are projected and then adjusted for special events by region-wide annualization factors, was believed to be underestimating potential transit demand in this particular corridor.

Research pertaining to public transportation patronage forecasting for special generators is limited. The literature is especially scant on the subject of the estimation of special generator mode choice and the incorporation of the forecasts in the traditional four-step travel demand modeling process. Ergun and Stopher[1] developed transportation demand models for urban recreational trips. Their research focused on the impact of socioeconomic and locational variables on a person's recreational activity choice. Their study did not specifically deal with mode choice, nor did it fit within the standard urban travel demand forecasting process.

A study by Pol, Ponzurick, and Rakowski[2] is more typical of research regarding the use of public transportation to and from special events. Their study developed demographic profiles of potential users and non-users of public transportation to sporting events, and used the profiles to forecast overall public transportation use. Again, their research is not directly applicable in the standard urban travel demand forecasting process and is not useful for our purpose of estimating ridership differences for transit alternatives. A third area of related research deals with induced travel demand for fixed-guideway alternatives. This work is based on data summarized from the Washington Metro system and, in short, is used to forecast additional non-home-based trips made between major activity centers after a fixed guideway system linking the activity centers is built. This work is based on the observation that traditional methods for estimating non-home-based transit ridership focus only on shifts among motorized travel modes and, therefore, have no sensitivity to changes in trip frequency or destination choice for non-home-based trips resulting from fixed-guideway investments. This procedure has been used to forecast induced travel for proposed fixed- guideway systems in Honolulu and Cleveland[3, 4].

The analysis process developed as part of the Gold Line study introduces a consistent procedure for special generator analysis. Drawing on traditional analysis methods, the technique is consistent with the modeling process used for regional travel forecasts for the Denver region. Moreover, the analysis process provides line-specific forecasts of the boardings that will result for various alternatives due to the special generators.

Special Generator Analysis Methodology

Special Generator Types

Special generators can be subdivided into three groups for travel forecasting purposes: *"regular" special generators*, *"periodic" special generators*, and *"special" special generators*. *Regular special generators* are those special generators that produce trips on a regular, weekday basis. Typical examples of regular special generators are airports, regional shopping centers, hospitals, and schools. To qualify as a regular special generator, a site or establishment should be open during the work week. This distinction is made since most urban travel forecasting is performed to plan for weekday transportation needs, with the implicit assumption that the transportation infrastructure and services supplied for a weekday will provide sufficient capacity for weekend demand. If annual revenues from the transportation supply (e.g., transit fares or tolls) are required for cost effectiveness analyses, they are generally estimated by applying annualization factors that include the contribution of weekend travel as a percentage of weekday travel.

Periodic special generators are those generators that do not produce trips on a regular weekday basis. Typical examples of periodic special generators are convention centers, stadia and arenas, and fairs and festivals. Because they occur relatively infrequently, periodic special generators are not normally considered in the planning for transportation investments since traffic-carrying capacity is not generally added to regional facilities nor are additional transit vehicles purchased to serve infrequent events. Because of their infrequent scheduling, it is assumed for transportation facility planning purposes that the transportation demands of periodic special generators can either (1) make use of available excess transportation system capacity (e.g., because they are scheduled at an off-peak time) or (2) create an acceptable short lived "breakdown" of the transportation system due to excess demand. While additional capacity is rarely added to the transportation system to serve periodic special generators, periodic special generators can be an important source of extra revenue for transit operators. This can result from event ridership using regularly provided transit service and from event ridership on specially provided service using surplus equipment (already available to serve normal peak demand). Of course, when special service is provided, revenues should be greater than operating costs in order for the provision of the service to be cost effective.

Special special generators include those sites or activities that cannot be easily classified as regular or periodic special generators. These special generators might include sites and activities outside of the modeling area. Travel on public transportation modes to and from external sites is often ignored because it is typically made on vehicles owned by private operators (e.g., intercity bus operators or charter buses). By definition, special special generators are unique and, thus, require individual analyses using ad hoc analysis procedures. In the Gold Line study, for example, the nearby ski areas and historic mountain community gaming districts west of Denver were considered as special special generators. The individual nature of special special generator analysis does not readily lend itself to the development of standard modeling procedures.

Regional travel models that include a special generator component for highway analyses also account for regular special generators for transit analyses. Regular special generators for highway analyses produce trips on a regular weekday basis and, due to differences in mode shares, impact auto travel forecasts long before they significantly impact transit ridership forecasts. Periodic special generators, however, often produce trips during periods that are not explicitly included in the regional modeling procedure. The focus of this paper will, therefore, be the evaluation of periodic special generators.

Periodic Special Generator Analysis Process

A principal reason for analyzing periodic special generators in a regional modeling sense is to determine additional revenue that would be generated for transit services. As stated previously, the travel demand associated with periodic special generators is not generally used to justify additional roadway or transit capacity. Trips from periodic special generators might, however, be considered in planning for the special generator site or special generator event. For example, transit and roadway improvements were considered in the planning for Coors Field in downtown Denver.

Periodic special generators of any size can be included in the analysis. Two practical considerations become important in determining size criteria: frequency of the event and size of the event. Large events, such as football games and baseball games are relatively infrequent, but are sufficiently important to receive special transit service. All large events should be included in the periodic special generator process. In Denver, using de facto criteria established in the region based on Colorado Rockies baseball attendance, large was defined as expected daily attendance of 40,000 or more. Smaller events (e.g., basketball and hockey games) typically do not receive specially provided transit service, but instead rely on regularly scheduled bus service. In Denver, the suggested size criteria for smaller events to be considered independently was 500,000 total annual attendees, or 8,000 average individual event attendees, as described below. If either criterion was satisfied, the site was included for analysis as a periodic special generator.

The total attendance criterion was calculated by multiplying the average event attendance by the number of events during the year. When the generator did not meet the size criterion by itself, it was bundled with other events occurring at the same site. For example, individual concerts at McNichols Arena (or the proposed Pepsi Center arena) were too small to warrant individual analysis. However, grouping concerts and other special events occurring at the specific sites provided sufficient attendance to warrant consideration as a periodic special generator. Other sites or groups of events were considered on an exception basis if they had sufficiently high visibility.

Trip generation, trip distribution, mode choice, and transit assignment models are required for periodic special generators. Modeling of periodic special generators is performed separately from the regional model. The periodic special generators require special files and model runs although some data and files from the regional model (e.g., auto "skim" trees) are used in the process.

Trip Generation

Trip generation for periodic special generators can be based on attendance projections. The normal daily trips to periodic special generator sites are accounted for in the regional modeling process. In Denver, for example, home-based work, home-based non-work, non-home-based, truck, and internal-external trips made to Mile High Stadium on an average weekday were based on the regular Mile High Stadium employment. However, travel to the stadium by "event" attendees has not been modeled in the normal regional travel forecasting process.

Estimates of attendees for most periodic special generators can be readily made. Attendance at sporting events, for example, can be estimated from past history. Attendance growth, in the case of sporting events, is often constrained by available seating. Two person trips can be modeled for each attendee to account for the trip to the event and the trip from the event.

Periodic special generator trips must be allocated to trip purposes. For events that occur on weekends, all trips can be assumed to be home-based non-work trips, although this assumption probably overstates the number of home-based trips and underestimates non-home-based trips since some attendees travel to or from the event to eating establishments, friends' homes, or work. For events that occur on weekdays, the attendee trips should be split between home-based non-work and non-home-based trip purposes. This split accounts for the higher likelihood of traveling to or from the event to or from work during the week. The split can be made in proportion to the regional shares of total trip ends by purpose (i.e., home-based non-work attractions, non-home-based productions, and non-home-based attractions). For events that occur on both weekdays and weekends, weighted averages for home-based non-work and non-home- based trips can be estimated.

Periodic special generator trips are projected on a daily basis. For sporting events, the daily basis is generally equivalent to one game. For other periodic special generators (such as an amusement park), a day is the appropriate time period for analysis. Each periodic special generator has a unique annualization factor. The annualization factor is simply the total number of annual events, or event days. For example, major league baseball teams play 81 home games each year, so the annualization factor is 81. The Taste-of-Colorado, an annual downtown Denver festival, is a three day event, so the annualization factor is three.

Trip Distribution

Home-based non-work and non-home-based trip attractions, and non-home-based trip productions are estimated for the periodic special generators. For home-based trips, the distribution of trips is somewhat simplified since they can be distributed from one attraction site (the special generator) to all production sites (i.e., home sites).

In the regional modeling process, symmetry between non-home-based trip productions and non-home-based trip attractions is assumed. In other words, non-home-based trip attractions are assumed to equal the non-home-based trip productions for each zone. For the periodic special generator process, this assumption of symmetry can be exploited to simplify the trip distribution process. Specifically, the non-home-based trip productions can simply be added to the non-home-based trip attractions at the special generator sites. This ensures that all periodic special generator trip “productions” take place at the non-special generator end of the trip, and all “attractions” take place at the special generator. The resulting distribution results can be used in the modeling process with no loss in generality.

Trip distribution of periodic special generators is simply a proportioning of trips from all parts of the region to a single site (for each periodic special generator). The basis for the proportioning will depend on the characteristics of each periodic special generator. For some sites, no sensitivity to travel time or distance in the region should be assumed. For example, there is no reason to assume that a resident of an outlying suburb is any more or less likely to attend a professional sporting event at Mile High Stadium than a resident of downtown Denver (if their socioeconomic characteristics are similar). Conversely, some special generator sites probably are sensitive to travel time or distance in the region. For example, residents of an outlying suburb are less likely to attend a downtown street fair than are residents of downtown Denver. Likewise, convention attendees at the Colorado Convention Center in downtown Denver are more likely to travel from downtown lodging establishments than from suburban hotels and motels.

Most special generator operators have little, if any, information regarding the spatial distribution of their attendees or consider the information to be confidential or proprietary. Since the information is not readily available, assumptions have been made regarding the basis for the distribution of trips to special generators. A basic choice must be made for each generator: the distribution should or should not be sensitive to time or distance traveled. The distribution can be considered to be independent of travel time or distance if there is no substitution event available. Thus, professional sporting events can be considered to be independent of travel time or distance. If a substitution event will be available, the distribution of trips to the site can be assumed to be affected by time or distance. Thus, events such as fairs and parades can be considered to be dependent on travel time since local jurisdictions provide similar events.

The distribution of trips to and from the periodic special generators can be made using a gravity model formulation. The gravity model is typically used to distribute trips from one origin to all destinations, not from one destination (i.e., the special generator) to all origins. However, the model can be applied in either direction. Zonal home-based non-work or non-home based productions can be used along with the periodic special generator attractions for the generator in question in the model application. The fact that the sum of the home-based non-work or non- home-based productions for the region do not match the special generator attractions for the special generator in question is not a problem in the application. The gravity model is “self normalizing” to the total attractions modeled for each special generator. Note that in the periodic special generator process, the model is applied independently for each special generator.

The values used for the friction factors in the gravity model determine the type of distribution performed. For a non-distance based distribution, all of the friction factors are set to 1.0, making the distribution independent of spatial separation and sensitive to only the relative distribution of trip productions in the production zones. For distance based distributions, the friction factors can be based on the home-based non-work and non-home-based trip distribution friction factors calibrated for the regional travel model.

Care must be used in the application of the gravity model to ensure that all inputs (i.e., productions, attractions, travel time matrices or friction factors) are consistent in terms of directionality. If special routines are used for the distribution, they can account for the fact that attractions are being distributed to productions while travel time matrices are from production zone to attraction zone. If a set gravity model program is "tricked" by inputting the special generator attractions as productions and the productions as attractions, travel time matrices should be transposed prior to the implementation of the gravity model, and the output trip matrices should be transposed (prior to the mode choice step) if normal mode choice procedures are used.

The distributions for each periodic special generator are, in effect, independent of each other. Distributions for multiple sites can be performed simultaneously, provided there are not two sites within one zone and provided that special travel time matrices are not subsequently required for mode choice. Note that for each periodic special generator, two distributions are performed— one for home-based non-work trips and one for non-home-based trips.

Mode Choice

Mode choice for periodic special generators can be accomplished through the use of the regional models for home-based non-work and non-home-based trips. The model must be run for each trip table created by the trip distribution step for the periodic special generators. Prior to the application of the mode choice model, the trips can be annualized by multiplying the appropriate trips for a periodic special generator by the appropriate annualization factor. This step simplifies the subsequent mode choice and trip assignment procedures.

Special transit path-building runs might be required for periodic special generators with special service such as professional baseball or football games. In this case, the special service must be coded into the network. Auto access to transit services can be assumed to be available for both home-based and non-home-based trips to the special generators. This will account for attendees that travel to events from eating establishments or friends' homes. Coded fares should reflect the service used. In other words, if a special service is used, the special service fare should be coded. Otherwise, normal fare policy should be coded for regularly scheduled services.

A number of changes to zonal data input to the mode choice program might be required. First, average event parking costs at the attraction zone should be coded for each periodic special generator. The parking costs should be adjusted to account for the average auto occupancy noted for each event. In addition, auto terminal times should be modified to reflect average walk times from parking lots to each of the periodic special generators.

Table 1: Sample periodic special generators for 2015

Site or Event	Assumed annual growth	Event days per year	Visitors/day	
			1995	2015
Colorado Convention Center / Currigan Hall	1.0%	250	3,420	4,170
Coors Field-Rockies Baseball	0.0%	81	48,000	48,000
Elitch Gardens Amusement Park	2.5%	121	7,470	12,240
Taste of Colorado	1.6%	3	116,700	160,30

Transit Assignment

Annual transit assignments can be performed for the periodic special generators. Since each periodic special generator can have a unique annualization factor, an annual transit assignment is a logical common time period available for the assignment process. Assigning the trips on an annual basis eliminates the need to perform separate transit assignments for each special generator. Since transit assignments are not capacity restrained, the assignment of annual trips does not cause any problems with the assignment process.

Example Application Results

Trip Generation

Table 1 summarizes the year 2015 trip generation results for four of the periodic special generators included in the Gold Line study. The annual growth factors listed in Table 1 are based on information provided by operators of the special generators, when available, or on the average annual percent growth in the region's population. The 1.6 percent rate assumes that attendance at special generator events will grow at a pace equal to the projected growth in population. Zero percent growth rates are for events that are currently constrained by seating capacity. Growth rates greater than 1.6 percent are based on information provided by operators of events. As previously discussed, each visitor was assumed to make two trips.

Table 2: Average travel times for trips to sample periodic special generators for 2015

Site or Event	Distribution basis	Average travel time in minutes	
		Home-based non-work trips	Non-home-based trips
Colorado Convention Center/Currigan Hall	Distance	22.6	22.6
Coors Field-Rockies Baseball	Non-Distance	34.5	32.5
Elitch Gardens Amusement Park	Distance	25.1	24.9
Taste of Colorado	Distance	23.2	22.9

Table 3: Annual transit trips and transit mode shares to sample periodic special generators for 2015

Site or Event	No-Build		Build	
	Trips	Share	Trips	Share
Colorado Convention Center / Currigan Hall	437,100	21.2%	447,600	21.7%
Coors Field-Rockies Baseball	1,208,100	15.5%	1,219,800	15.7%
Elitch Gardens Amusement Park	865,200	29.3%	881,200	29.8%
Taste of Colorado	372,900	38.8%	372,900	38.8%

Trip Distribution

Table 2 summarizes the average travel times to the periodic special generators. The distribution basis (distance based or non-distance based) is also shown. As can be seen, the distance based average travel times are shorter than the non-distance based distributions.

Mode Choice

Mode choice is dependent on numerous items including auto and transit travel times and costs. The regional home-based non-work and non-home-based mode choice models were used to project periodic special generator mode shares. Several changes were made to the models in order to replicate base mode shares. Specifically, parking costs were adjusted in the special generator zones to reflect weekend, nighttime, and event parking costs as appropriate, as well as assumed and observed auto occupancy rates. Auto terminal times were also modified for Colorado Rockies Baseball games. The revised auto terminal times reflect longer walk distances from parking to Coors Field and increased congestion approaching and leaving the venues. Finally, special transit services for Rockies games were also coded.

Table 3 summarizes the overall mode choice results for the example periodic special generators for two of the alternatives tested. As can be seen in the table, transit mode shares to the periodic special generators are relatively high. In comparison, general home-based non-work and non-home-based transit mode shares for the region average about 11.5 percent in the CBD and 1.2 percent outside of the CBD. The high mode shares are due, in large part, to the CBD or CBD fringe location of many of the events along with the relatively high parking costs charged for many of the events.

Transit Assignment Results

Table 4 summarizes the results of the transit assignments of the annual periodic special generator trips for the Gold Line study. The results summarized in Table 4 include only periodic special generator trips by event attendees. Table 4 also shows projected annualized weekday boardings as a basis for comparison.

The annualized weekday boardings implicitly include the periodic special generator boardings through the annualization factor, 302. That factor is based on historical data comparing annual system wide boardings to average weekday boardings. However, the projected annual periodic special generator boardings for the build alternative range from about 4 percent of the annualized estimate for Limited/Rapid Transit Feeder service to about 9 percent for the Regional/Express

Table 4: Regional transit assignment results for 2015

Type of transit service	Annual periodic special generator boardings		Annualized boardings[a]
	No-Build	Build	
Local Bus	4,055,300	4,060,300	52,805,300
Limited/Rapid Transit Feeder	305,300	311,900	8,324,000
Regional/Express Bus	688,200	628,500	6,872,000
Light Rail/Air Train	2,489,100	2,523,300	30,455,800
Gold Line Rail	n/a	130,000	1,774,300
Total	7,537,900	7,654,000	100,231,400

a. Annualized boardings are summarized from 2015 projections for regular weekday transit.

Bus service. This implies that the explicit modeling of periodic special generator ridership can produce more realistic forecasts of annual boardings and revenues. Of course, adjustments to the annualization factor are required to avoid double counting in annualized totals.

Summary

An analysis process for assessing the impact of special generators on transit ridership projections has been developed and demonstrated in a study performed for the Regional Transportation District in Denver, Colorado. The special generator analysis process provides a consistent and rigorous method for comparing special generator ridership projections between alternatives and corridors.

The special generator process works within the regional transportation planning process used for the Denver region. In the future, it might be desirable to collect data and calibrate trip distribution and mode choice models unique to the special generators. However, since those data are currently not available, assumptions that travelers react to travel options in a similar manner as for normal weekday travel have produced reasonable results.

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The Community Options Model©: Using Artificial Intelligence for Transportation Planning and Community Decision Making

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Abstract

This paper describes the Community Options Model for Transportation-Related Issues. COMTRI is designed to help both the Michigan Department of Transportation (MDOT) and individual communities "see" the likely outcomes of potential highway realignments and other changes, and of potential community responses to such changes. It predicts the change in community indicators over time—such as population, jobs, income, unemployment, tax rates, local government income and spending, property values, vehicle trips and congestion, education attainment, and community services quality—in response to policy or action scenarios posed by the user. The model is equally useful for evaluating a wide variety of non-transportation community options for community development.

COMTRI is a hybrid knowledge-based and statistics-based systems analysis of community social, economic, and transportation systems and their responses to exogenous action and policy scenarios. Knowledge-based simulation models are simple forms of artificial intelligence, in which the model's equations—and thus its predictions—are constructed to mimic the thinking of experts on the topic. They can utilize available human knowledge to specify relationships that would be impractical to estimate statistically.

COMTRI's structure and equations were initially specified in general form by a group of experts and practitioners. Its details were specified as necessary to predict actual conditions in three-case study communities over the period 1980-1992. The resulting model "thinks" and predicts much as the team would if it could integrate its collective best thinking to predict the indicators over time, but using some 400 equations that have been fitted to statistical data.

COMTRI is designed to be used by rural communities throughout Michigan. We describe how several Michigan communities are using COMTRI interactively to evaluate the effects of their own potential policies and actions. Extensive detail about any given community must be entered into the model to predict outcomes specific to that community.

The example first estimates the likely community impacts of possible highway realignments (bypasses) being considered by MDOT. Then we explore community options for responding to these changes. Bypasses tend to redistribute retail sector activity from former thoroughfares to new bypass intersections. Other economic development also follows eventually, further influencing traffic volume and flow.

Local strategies for increasing retail sales can increase local employment, which in turn increases population and local expenditures for education and other services. Changing tax revenues and demands for services create pressures to increase or decrease property tax rates.

By exploring a variety of options, communities can identify strategies that are more likely to produce the outcomes they prefer. Skillfully used, such information can help unify community efforts, which should increase the community's chances of reaching its goals. Further, with the model the MDOT's formal economic and environmental impact assessments can now specify how the impacts of a given realignment may vary depending upon the community's response to the change.

Road agencies and communities are often intensely interested in the local impacts of road improvements. Socioeconomic impact assessments are usually intended to provide most of the information agencies need to evaluate projects from the public point of view. Such assessments should form the heart of agency and public debate regarding which actions and projects should be undertaken.

Impact assessments are rarely utilized this way. They are almost never used to help formulate the best actions or project options. They are much more likely to be used to confirm or support choices that have already been at least tentatively decided.

We believe economic and social information is underutilized primarily because such information is expensive and not readily available. Scientific tools and statistical data have been of little help in predicting the outcomes of local changes to highway networks. Econometric or land-use allocation models work only at the largest scales, and often the small-scale impacts generate the most controversy. Planners usually resort to judgment based on observation of similar cases and local conditions. Further, socioeconomic information is poorly understood by the general public, and is often estimated and presented in a confusing variety of formats. However, these latter problems would probably subside if the information were used more often.

These limitations may soon evaporate. Widespread use of personal computer technology and new simulation model techniques can make such information quickly and easily available.

This paper describes one such personal-computer application program: the Community Options Model for Transportation-Related Issues (COMTRI), designed to estimate the social and economic impacts of highway realignments on rural Michigan communities for the Michigan Department of Transportation (MDOT).

COMTRI allows MDOT and individual communities quickly "see" the likely outcomes of potential highway projects, and of potential community responses to such projects. It predicts the change in community indicators over time — such as population, jobs, income, unemployment, tax rates, local government income and spending, property values, vehicle trips and congestion, education attainment, and community services quality — in response to policy or action scenarios posed by the user. COMTRI also estimates the impacts of a wide variety of potential community responses to highway realignments as well as the impacts of local community development actions such as granting tax abatements.

This paper describes COMTRI and its use in estimating the socioeconomic impacts of highway projects. We first describe the rationale for developing the model for use by a transportation agency. Following that, we describe how the model's framework was specified by a multi-disciplinary group of experts and practitioners, and its equations were fitted to data from three case-study communities. The fourth section illustrates use of the model in estimating the impacts of a highway realignment in one of our test communities. It describes the types of qualitative and quantitative community information required to initialize the model — usually involving some community self-assessment — and the types of information estimated by the model. The examples also illustrate how decisions made by the community can change the impacts of the realignment. We conclude that COMTRI's rapid and comprehensive impact estimates could be used as a decision support system in planning and decision making processes. By exploring a variety of options, the agency and communities can identify strategies that are more likely to produce the outcomes they prefer. Skillfully used, such information can help unify community efforts to cope with and take advantage of the local impacts of highway realignments. New technology and new approaches to model development and estimation have made it possible to develop and utilize large, comprehensive models such as this.

Rationale For COMTRI

This project began as a response to highway-improvement projects in Michigan. MDOT needed forecasts of the impacts of alternative improvement schemes on small cities, including relocations of state highways bypassing main streets, freeway extensions, widening of main streets and one-way pairs:

- Project planners needed to resolve controversy between competing client groups.
- Highway-agency managers needed to choose between proposed alternatives.
- Environmental staff needed to forecast project impacts for NEPA reporting.
- Local residents and entrepreneurs wanted to know how proposed alternatives would impact their neighborhoods and businesses, how to manage adverse impacts, and how to take advantage of new conditions.
- Local planners wanted to build on the improvement for community growth.

Demands for Impact Assessments

These customers all demanded *quantified* forecasts of impacts, typically focusing on retail sales, but also including land development, residential migration, employment growth and quality-of-life issues. Local officials and the public often presume that it is practical to produce detailed forecasts of the performance of business sectors, not understanding that at the local level these sectors consist of a very few actors, and that few relevant statistics are available for small communities.

Further, public debate over impacts often focuses on highly-visible or notorious issues — for example, the impact on established retailers when traffic is relocated to a new route, or the competitive position of a destination relative to places made effectively “closer” by a new road. From the viewpoint of the project planner, it would be desirable to focus more debate on impacts on the whole local economy rather single components. A simple, systematic analysis of the whole community may place individual gains and losses in perspective.

Strengths and Inadequacies of Traditional Approaches

Traditional approaches to impact assessment have often involved:

- Synoptic judgments by one person, such as a planner, sociologist, consultant or other expert.
- Check-off lists of potential impacts, perhaps amplified by weighted multi-objective evaluation criteria.
- Case studies after the fact, used as predictors in comparable cases.
- Custom statistical analyses for projects large enough to have statistically-meaningful populations.

Case studies have formed the backbone of forecasting tools for impacts on local development, especially for retail and residential location and other land development. This has been the most reliable approach until now. Studies of small-town bypasses, for example, now number in the hundreds; so many that the accumulated mass of studies now provides a basis for statistical study. But the case-study approach has a key failing: even a large number of prior cases is insufficient to consider all of the factors that influence the outcomes in any individual instance.

Ideally, a general statistical model could be adapted for use in small communities. For instance, land-use allocation models have been used for some time in parallel with regional transportation system models, and econometric and input-output models are being used to test the economic worth of very large-scale road system changes, such as new multi-state freeways. However, such models are inaccurate at the community level and estimate few of the variables needed.

Integrating Expert Knowledge and Statistical Data

COMTRI is a hybrid *knowledge-based and statistics-based systems analysis* of community social, economic, and transportation systems and their responses to actions and policies.

COMTRI's structure and many key equations were initially specified in general form by a group of experts and practitioners. Knowledge-based simulation models are simple forms of artificial intelligence, in which the model's equations — and thus its predictions — are constructed to mimic the thinking of experts on the topic. Such models can utilize available human knowledge to specify relationships that would be impractical to estimate statistically.

The equations that make up COMTRI were then estimated by fitting them to data from three case-study communities over the period 1980-1992. The resulting model "thinks" and predicts much as the team would if it could integrate its collective best thinking to predict the indicators over time, but using some 400 statistically estimated equations.

Expert-Based Framework for COMTRI

COMTRI began with a workshop on transportation and community development in April, 1993. The workshop followed a procedure largely based on the Adaptive Environmental Assessment workshop technique developed by the International Institute of Applied Systems Analysis (Holling, 1978; Walters, 1986). The workshop specified which components to incorporate into COMTRI, and their general interrelationships. The 21 participants included academic researchers in economics, sociology and demography, several transportation engineers, and several community development practitioners, including state, regional and local planners and community development specialists, two city managers, a city assessor, a township supervisor and a city administrative assistant.

The workshop first listed some of the current issues facing rural Michigan communities undergoing major highway realignments. *Communities* were defined as any population (under 30,000) that identifies with and frequents a central rural location, and the cities, villages and/or townships they inhabit. Then, in view of these issues, the workshop listed the indicators and actions they wanted the model to predict and simulate. *Indicators* are the information people use to keep track of conditions over time, such as population, unemployment rate and average daily traffic. Table 1 lists the categories in which the approximately 400 indicators in COMTRI are grouped. The objective of the model is to predict these indicators over time under specified scenarios. *Actions* are the changes or options that are to be evaluated by the model. Table 2 lists most of the actions suggested by the workshop. Some actions are policy changes or components that can be implemented by MDOT or by the community, such as *highway realignment, park development, or cre-*

ating a Downtown Development (tax-increment capture) Authority (DDA). Other actions may be exogenous events outside the control of the community, such as changes in *state economic conditions* or *relocations of plants or employees*.

The indicators were grouped into ten *sectors* (Table 1). Participant subgroups specified which variables and general equation forms predict change over time in each indicator. For instance, the economics subgroup specified a variation on standard economic frameworks for predicting earnings and employment by sector in the community. That is, employment in the services, construction and local retail sectors depends largely upon total community personal income, employment in the retail mall sector depends in part upon the amount of community income derived from outside the community, and employment in manufacturing and several other sectors depends largely upon state and national trends. Subgroups also specified some additional variables produced in their sectors that other subgroups needed for estimating their indicators.

Table 1: Sectors and subsectors of COMTRI

Population	**Labor Force/Commut./H'holds**
Population by 7 age classes	Labor force & commuting
- Population density index	Households
- Senior attraction index	**Property Values**
Economy	Residential/developmental
Retail/wholesale	Commercial
Travel/tourism	Industrial
Construction	Agriculture/forest./open
Services/FIRE	Personal property
Manufacturing	**Community Services; Indicators**
Mining/trans./utilities	Recreation/tourism
Education	Institutional services
Government	Community indicators
Agr./forestry/fisheries	- Cost of living
Earnings	- Cost of government
Economic base	- Crime
Transfer payments	- Housing
Personal income	- Education attainment
Economic attractiveness	- Social services
Retail Land Use	**Public Budget**
Retail & traffic x bus. district	City & township taxes
Traffic Volume & Safety	Education taxes & budget
Volume by road link	City/village/twp revenue
Local trip generation	City/village/twp expenditures
Corridor volume/speed	County health/welfare/judicial
Traffic safety indexes	Fiscal equity
Seasonal Population & Lodging	**Community Organization**
Lodging	Self investment
Camping	Competence index
Seasonal homes	Attractiveness index

These variables and interrelationships form an initial outline or framework for an expert-based systems analysis of community socioeconomic and transportation systems composed of:

- perspectives and findings of several scientific/engineering disciplines,
- practitioners' and trades' explicit and implicit rules of thumb, and
- best judgment regarding relevance and interrelationships of systems and components.

Equation Estimation

After the workshop we began estimating the approximately 800 individual equations that comprise the simulation model described at the workshop. The equations are grouped into 10 sectors and 42 subsectors (see box). Roughly half of the equations perform "housekeeping" operations, such as integration, summation, or recording constants, so did not require statistical estimation or verification. The other half, representing real-world phenomena, were estimated or verified using data from Michigan communities.

Table 2: Actions proposed by the workshop to the simulated in COMTRI (partial list)

Transportation options:	Inter-community cooperation
Bypass (freeway, limited access, highway access)	Support services for elderly, etc.
Improve (widen, controls, straighten, 1-way pr.)	Limit signs or noise
Highway access controls: Curb cuts, blvd vs 5-lane	Park development, scenic preservation, open space
Controlling water/sewer hookups	Provide off-street parking; on-street parking
Zoning extent and intensity	Increase pedestrian capacity
Master planning; corridor planning	Public communication: attitude surveys, meetings, etc.
Community strategic planning	Develop public & private campgrounds, marinas, etc.
Economic development activity (EDA, DDA, etc.)	Beautification programs
Tax abatements	Promotion; Adopt a theme for the community
Change tax rates (mileage, income tax rates)	Local budget reallocations
Industrial parks; Business incubators	Annexation/separation; 401(5)'s (revenue sharing)
Permit planned unit developments	New state tax laws
Airport development	State/national economic conditions
Educate/train local work force	Local competitive position for retail, tourism, etc.

Most equation forms were specified in the workshop, and simply needed to be fitted to actual data. We fitted equations to 1980-1992 data from three rural Michigan communities for which through traffic had been rerouted away from the downtown areas during the mid-1980s. We initialized the model to each community for 1980, then compared predictions of any equations to be fit to actual data from the community for 12 years: 1981-1992. Each equation was modified first to reasonably predict conditions in one community, then two, and eventually all three communities. In effect, each equation was fitted "manually" to data from the three communities. Rather than using a least- squares measure of fit, we considered the percentage error of prediction for the variable and for its sub-sector, the degree to which the equations influenced predictions of other parts of the model, and the degree to which the equations conformed to the model outline provided by the workshop.

It was necessary to consider more than simple statistical fit in specifying our equations because "everything is connected to everything else" both in the real world and in the model. Variables in the model are generally interdependent rather than dependent or independent as assumed in statistical estimation. For instance local population migration depends in part on local unemployment rates, and local unemployment rates depend in part on the size of the labor force, which in turn depends in part on local migration. We generally had to fit several equations simultaneously rather than one at a time.

For example, the final equations were able to predict the 1990 total population of each community within about 3%, given the communities' 1980 population and full knowledge of unemployment rates for the entire period. COMTRI estimates the population of each age class separately, and it predicted the population of each age class for each community within about 12%, except the 18-24 year age class in one community was overestimated by 21%. The communities' experiences in the period ranged widely, so we have reason to believe that the fitted equations will also predict well for other Michigan communities. The population of one of the communities, Reed City in northern lower Michigan, grew by nearly 6% during the period, while its unemployment rate remained below the state average. Another, Manistique in the Upper Peninsula, lost about 5% of its population while unemployment was higher than the state average, whereas the third, Lapeer in southeastern Michigan, grew by over 7% in population while experiencing below average unemployment rates through 1985, then above average.

The workshop did not specify some equations needed in the model. In such cases we generally asked practitioners or academic experts to help specify them, and then we followed the above equation fitting process. However, no one could definitively explain rural community-level population migration and school funding decisions, so we tested several possible explanations using data from communities statewide. For instance, we concluded that rural migration of high school graduates (18-24 year age class) responds more to the weighted average of community (20%) and county (80%) unemployment rates than to absolute or relative state or national unemployment rates. Specifically, we rejected hypotheses (1) that increased migration out of cities during periods of high statewide unemployment would increase migration of this age class to rural areas, and (2) that rural residents of this age class migrate significantly to other states when local unemployment rates are much higher than the national average. The next two age classes (25-44 and 45-64) also respond to the same factor, but are less sensitive to it and are influenced by other factors as well.

Data for several qualitative indicators and relationships were not available through normal statistical sources. In these cases, we asked community representatives to rate their communities on a percentile scale relative to other Michigan communities over the time period. We assumed that these ratings were accurate and used them to estimate equations predicting change in indicator levels over time. We also asked community members to critique COMTRI results and forecasts, particularly considering these qualitative variables.

As a final stage of model development, we are testing the model as a practical decision support tool in three other rural Michigan communities for which new highway projects are proposed. Predictions that differ from expected outcomes will be reexamined and respecified if appropriate.

Geography; Road Network and Land Use

The road network in COMTRI is highly simplified, consisting of ten nodes and links representing the major intersections and traffic flows. Through-traffic forecasts are exogenous, but changes in local auto and commercial traffic volumes are endogenous. COMTRI models community responses to masses of through and local trips, not trip generation or assignment to a network. One link may represent more than one actual road in a corridor. Transportation alternatives are represented to the model by designating the percentages of through and local auto and commercial utilizing each link. Links not existing in an alternative have zero traffic. Level of service is represented by the travel time through the community.

Land use is also highly simplified. Only retail-sector land use is predicted, in each of five business districts. Each designated business district is associated with one or more road links. The retail sector is both influenced by and influences traffic volume on those links. Because land-development impact is an issue in road improvement, we considered modeling land-use allocation in more detail in COMTRI, but we decided that would unnecessarily complicate this edition of the model. Since COMTRI estimates employment by economic sector, number of households and commuting, its land-use allocation sector could be expanded later.

Modeling Software

COMTRI was written in a systems analysis and simulation software, STELLA II®. It and its competitors, such as Powersim® and Vensim®, provide graphic tools representing systems components and processes, and are adept at handling calculations and graphing output. Its arrows and circles represent variables and relationships, and the process forms its own flow chart.

Unlike a spreadsheet, this software is designed to deal with circular (co-dependent) relationships. Feedback loops are handled by timing delays and iterations (commonly used in biological models), rather than by simultaneous equations (commonly used in economic models). Users specify the number and frequency of iterations. (COMTRI cycles quarterly for 16 years.)

The software helps one explore and clarify fuzzy or poorly-understood relationships. Functions can be entered as equations or graphs (tables of data points). If the equation of the curve is not known, or if only a few data points are known, the user can draw a proposed curve and the program will supply the missing data points. Variables or sectors can be held constant for one run, and allowed to change in the next. It also provides for easy sensitivity testing of individual variables.

Comparing Outcomes For Transportation and Community Options: COMTRI as a Decision Support System

Each community is unique. To depict a specific community, COMTRI must be initialized with data describing local conditions. Then it predicts *changes* in those conditions over time under any given scenario for the future. Therefore, initialization in effect creates an unique model specific to that community. Table 3 lists the major types of initial data and their sources. These data are similar to data typically assembled in the environmental-scan phase of community strategic planning. Data include qualitative self-ratings by community members as well as statistical data.

Table 3: Local data needed to initialize COMTRI (sources in parentheses)

Current population by age (Census, Mich Dept Mgt & Budget)
Current employment & earnings by sector (BEA)
Current property values (SEV)
Current housing and occupancy, recent construction (Census, building permits)
Community street/highway system schematic of primary routes (mapping guidelines provided)
Traffic flow volumes, patterns & related data (MDOT)
[Optional: Earnings per work projections (derive from BEA)]
Transfer payment projections (derive from BEA)
Current & expected competitive position & econ conditions (guidelines provided)
Current & expected public budget allocations, LDFAs, DDAs, etc.
Current & expected school funding allocations
Self assessment of quality-of-life indicators (guidelines provided)

The process of assembling these data can in itself provide useful insight for community members, and may help them understand the model's workings and gain confidence in its results. It may also help prevent the public-involvement process from involving only persons with specific complaints about a project. We hope the model will help limit undue focus on relatively small but highly-visible impacts such as on a block of bypassed businesses or a neighborhood subjected to increased traffic or detours. Such issues must be considered, but undue focus can prevent due consideration of much larger community-wide benefits and costs.

Figure 1 illustrates some impacts of a highway realignment (freeway bypass) completed in early 1987 at Reed City, Michigan, one of our three case-study communities. Bypasses tend to redistribute retail sector activity from former thoroughfares to new bypass intersections. Average daily traffic on the downtown corridor (Variable 1, ADTDnTn) drops in 1987, followed by the downtown corridor's volume of traffic relative to that in other districts (Variable 2, DnTnTrafShr), and

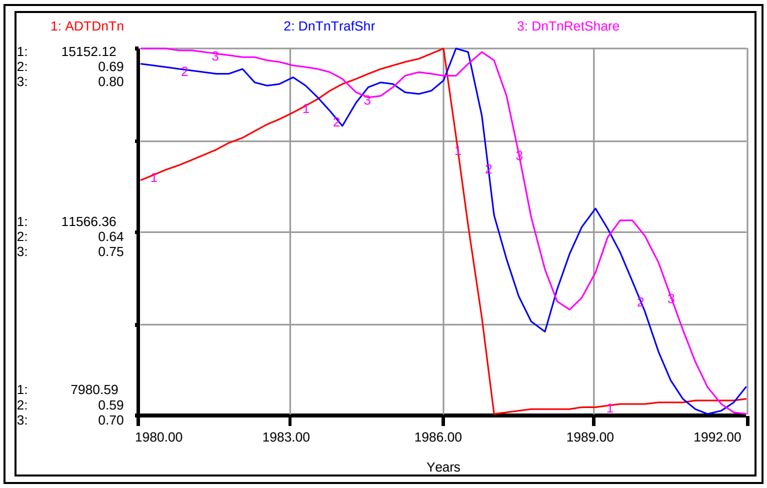

Figure 1: Traffic volume and retail employment share for Reed City's downtown district, 1980-1992

by the downtown business district's share of retail activity (DnTnRetShare). Traffic share and retail share actually dropped at the same time as traffic volume, but delays built into the model result in the lags in predictions. COMTRI predicts retail employment in each of five designated business districts as a function of traffic volume and other factors. Retail employment in turn influences traffic volume. Other economic development also follows eventually, further influencing traffic volume and flow.

The following example explores community options for responding to changes such as these. Local strategies for increasing retail sales can increase local employment, which in turn increases population and local expenditures for education and other services. Changing tax revenues and demands for services create pressures to increase or decrease property-tax rates. By exploring a variety of options, communities can identify strategies that are more likely to produce the outcomes they prefer.

Skillfully used, such information can help unify community efforts, which should increase the community's chances of reaching its goals. Further, with the model, MDOT's formal economic and environmental impact assessments can now specify how the impacts of a given realignment may vary depending upon the community's response to the change.

Our example explores the development of a mall or similar outlying retail complex at a new, heavily used intersection created by a bypass. COMTRI predicts "mall" development as a function of (1) a rule-of-thumb employed by developers, (2) community policies toward mall development, and (3) the influences of competitors. The rule-of-thumb is that development is not feasible unless the potential market (MallPop in Figure 2) — the population within 15 minutes' drive (AreaPop) plus 1.5 times average daily traffic (ADT...) adjusted for competition — exceeds a threshold of 45,000 (MallThreshold). The adjustment for competition (MallMktPosition) assumes that people utilize the closest retail anchor stores, so all residents of the 15-minute zone

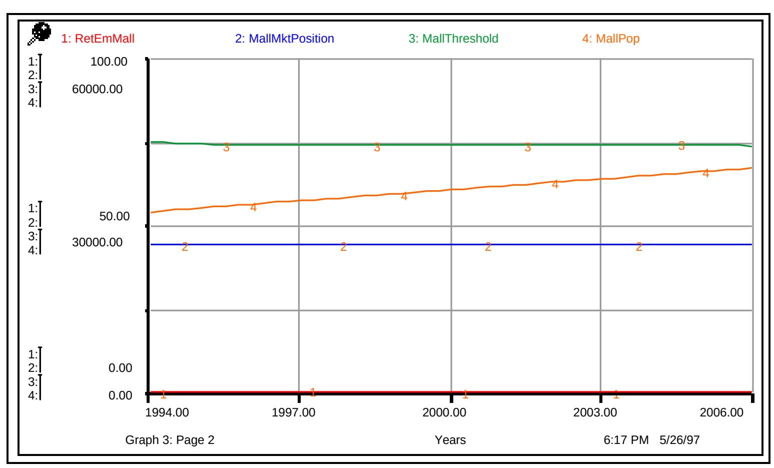

Figure 2: Mall development variables under baseline assumptions

closer to a competing anchor store are subtracted from AreaPop. This subtraction is also modified by the size of the competing malls or stores. I.e., larger competitors reduce AreaPop more. Also, MallThreshold is a moving target, rather than being fixed at 45,000. It is influenced by community ability to accomplish goals (the *community competence index*), zoning laws, and the availability of water and sewer lines to the mall site. According to practitioners, anti- mall zoning and water and sewer restrictions can delay, but not stop, mall development.

In COMTRI, these restrictions raise (or lower) the mall development threshold. Figure 2 illustrates COMTRI's baseline prediction for Reed City, in which MallPop does not reach MallThreshold by the year 2006, so retail employment at malls (RetEmMall) remains zero. Figure 3 illustrates Scenario 1, in which one of the competing anchor stores moves away and is not replaced, reducing competition, and thus opening the market to mall development in Reed City. MallPop crosses MallThreshold, and mall employment begins soon after. By comparing baseline projections of indicators — such as the community's annual unemployment rate (AnnUnemp), total retail and wholesale sector employment (RetailEm) and resident population (TotalResPop) — to their levels under each scenario, users can evaluate the impacts of specific actions or conditions affecting the community (Figures 4 and 5).

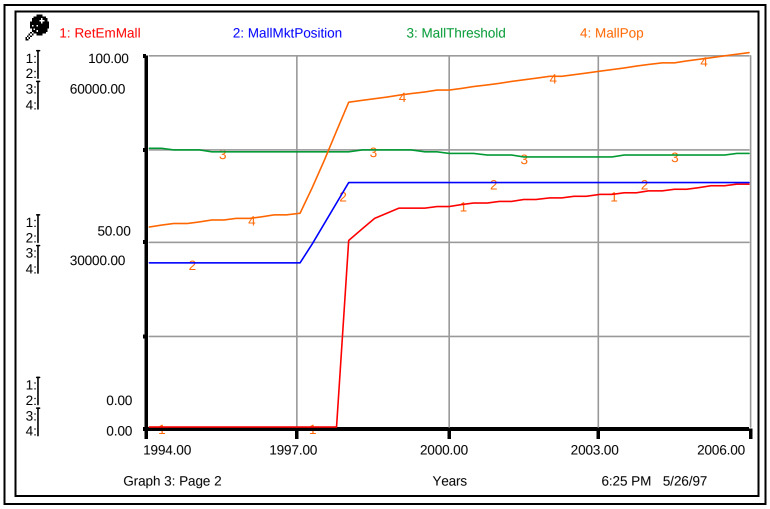

Figure 3: Mall development under Scenario 1: loss of competing store

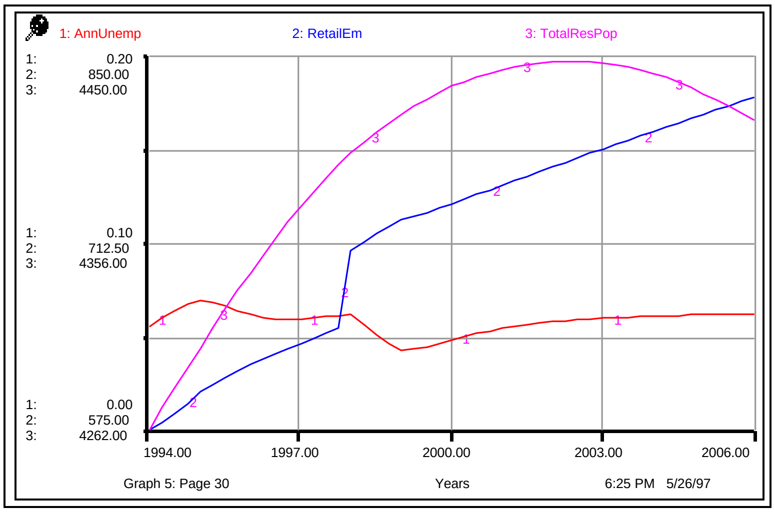

Figure 4: Baseline projection of unemployment rate, retail employment and population

Figures 6 and 7 illustrate the impacts of the new retail development on five other indicators: PedestrianCirc and DnTnCongestion are indicators of the suitability of the downtown district for pedestrian use and of the apparent level of congestion in the downtown district; both are based on community self-ratings of the two indicators on a percentile scale (0 to 100) compared to other similar Michigan communities. DnTnDrTime is an estimate of the average number of minutes required to drive a designated length of the main corridor through the downtown district during peak traffic; SEV Total is the estimated total (for the community) state-equalized assessed value of tax able prop-

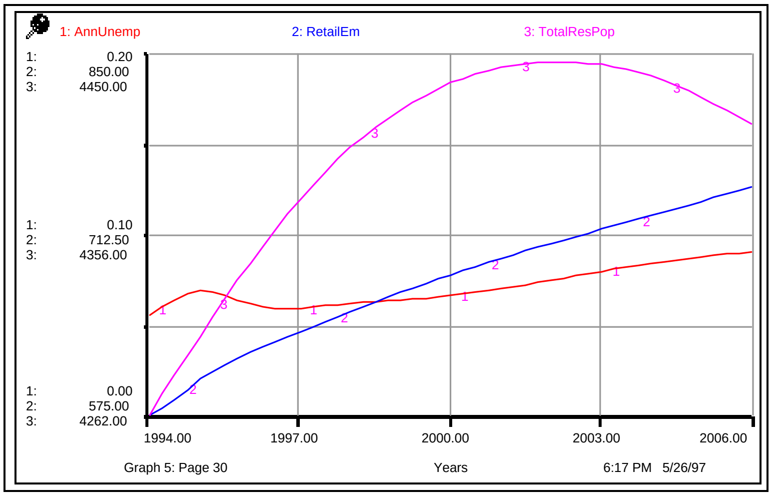

Figure 5: Unemployment, retail employment and population in Scenario 1

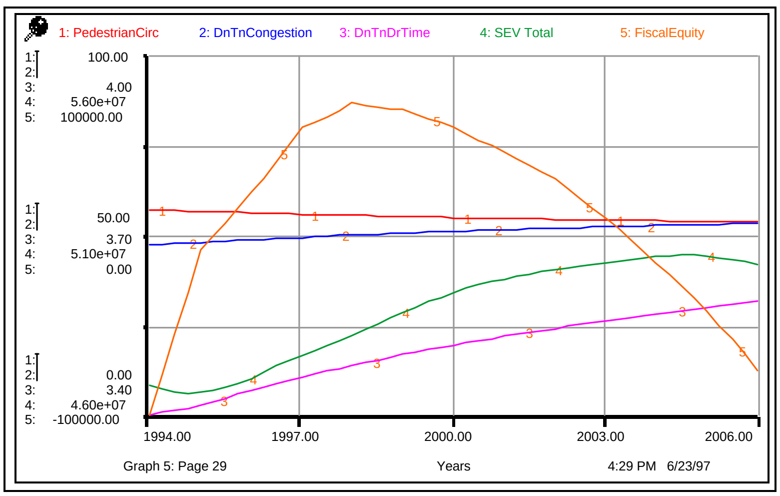

Figure 6: Five indicators estimated under Baseline assumptions

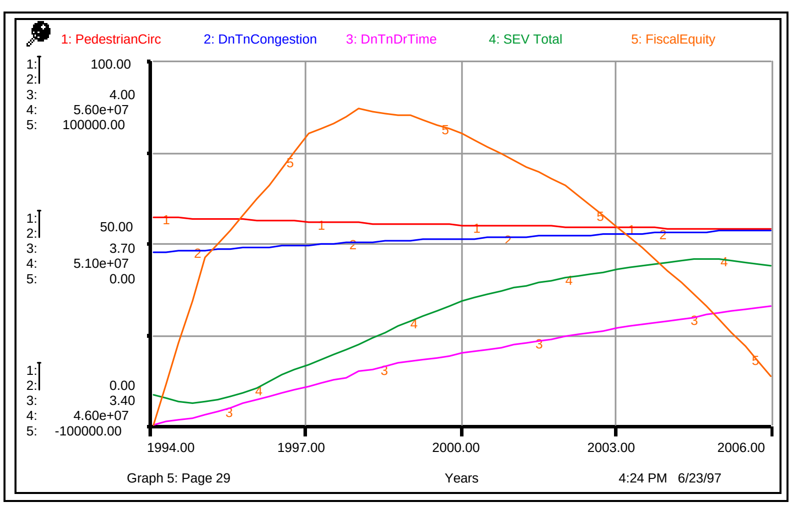

Figure 7: Five indicators estimated assuming Scenario 1

erty; and FiscalEquity is the accumulated fiscal position of all governments in the community, in which positive numbers represent net savings and negative numbers represent net borrowing in dollars. Figure 6 predicts these five indicators under Baseline assumptions, and Figure 7 predicts the same indicators assuming Scenario 1. COMTRI estimates about 400 indicator variables, though communities would usually examine more than a few indicators only for scenarios in which they are particularly interested.

COMTRI as a Decision-Support Tool

COMTRI was designed to address the often-intense public interest in the outcomes of highway improvements. Our intent is that COMTRI be integrated into the project-development process, helping simultaneously to predict impacts and inform debate. We believe this information can provide a common ground for resolving competing interests and views within an agency or a community.

COMTRI is intended to be operated by the state highway agency, but could also be used by a city government, planning commission, consultant, or advisory agency. COMTRI's initialization process — compiling a description of the community's socioeconomic environment and a self-assessment of qualitative indicators by community leaders — would ideally be a cooperative process between the agency and the community. This *cooperative* process and initial review of the community's socioeconomic environment is important in itself, in some cases perhaps more so than the results. Input from a variety of community groups will help widen and promote public-involvement.

The model's impact estimates can substitute for a state agency's or consultant's, although they may not be accurate enough to be the sole guide for local investment decisions. The many outputs from the model can enable a community to see all the major impacts of a highway project at once, or the lack of impacts. We hope use of the model will reduce the tendency of debates to focus on single, highly-visible impacts.

MDOT is committed to cooperative planning of projects within communities, and we think this model has potential to provide a common ground on which such debates can be resolved.

Profiting from Change — Use of the Model by Communities

Use of COMTRI makes it obvious that outcomes depend both on the nature of the highway project and on the community's response to the project. Conventional impact assessment is a *ceteris paribus* process in which the proposed project is the only variable, and analysis stops when construction starts. But for the community, construction of the project marks the beginning of an infinitely-variable future. Before the project is built, COMTRI lets communities start visualizing alternative ways to ameliorate impacts, exploit improved access, and see the results of different growth or growth- reduction policies and other public investments. Highway alternatives are not the only alternatives that can be tested; the model is equally suited to testing alternative —

- local public investments
- levels of taxation and public services
- policies that encourage or discourage growth, and
- tourism marketing schemes.

A community can test the outcome of alternatives given different conditions. For example, the model is well suited to foreseeing the impact of the opening or closure of a large employer. The impacts of the public project can be tested given a rosy forecast of the future (with the employer), or a worst-case scenario (without the employer), or anywhere in between. Local-government investments can also be tested in tandem with the highway project. The model is adept at testing the impact of schemes to increase tourism, and predicting the ability of a town to compete with similar destinations for recreational trade.

Conclusions

COMTRI represents a new approach to socioeconomic impact assessment of highway projects: a computer program for desktop computers that can instantaneously estimate project impacts on hundreds of indicator variables. One can quickly evaluate a variety of project development scenarios, plus a variety of possible community responses to the projects.

Three relatively recent developments have collectively made it feasible to create and utilize such models. First, two new approaches to model estimation make it possible to estimate detailed models involving hundreds of interrelated equations. We utilized expert knowledge to design the overall model framework, then fitted its equations or equation sets to time series data from diverse case study communities. The experts narrow the focus of the model to the most relevant aspects, and contribute rules-of-thumb and other understandings of community social and economic life. The equation fitting process contributes a relatively objective assessment of individual relationships.

Second, commercial simulation-modeling software greatly facilitated model development and statistical fitting.

Third, people are becoming more capable of understanding and utilizing graphical data and other kinds of indicators produced in COMTRI. The widespread use of personal computers, use of the worldwide web, and media use of such data and indicators have familiarized many people with these kinds of information.

The stage now seems set for socioeconomic impact assessment to become an effective, real-time decision support system for transportation agencies as well as for communities. Perhaps equally important, such models permit communities to independently examine the impacts of proposed highway projects and their own options for responding to them. This could strengthen and help unify community efforts to cope with and take advantage of the changes caused by highway projects. However, the models' most widespread use may be as decision support systems for community development in general: Communities can proactively explore a wide variety of community development options that may or may not involve transportation system changes.

COMTRI also appears to be a great learning tool. The model specification and development processes were quite educational to participants. So far, users of the model also have consistently found its perspectives on cause and effect to provide interesting insights. It should prove valuable to students in formal educational settings as well. Explorations can range from practical questions about options for managing a community's future, to academic questions about the processes by which communities develop their unique characteristics over time.

Finally, we recommend that socioeconomic impact assessments estimate a range of possible impacts de pending upon possible community actions, rather than assuming there can be only one set of impacts. Use of the model makes it obvious that community responses help determine the impacts of a highway project. That is, the same project could have one set of impacts when the community responds in one way — such as encouraging economic growth — and a different set of impacts when the community takes a different tack.

A Comparison of Travel Survey Methodologies

Madhuri S. Korimilli and Ram M. Pendyala, University of South Florida

Abstract

Travel surveys have served as the predominant source of information on travel demand characteristics, travel behavior, and origin-destination patterns for several decades now. Over the years, many different travel survey methodologies and survey instruments have been adopted and applied in various contexts around the world. The diversity, variety and complexity of travel survey methodologies and instrument designs has been recognized by the transportation planning community as an issue facing transportation planning agencies around the country. At a Conference on Household Travel Surveys held in 1995 in Irvine, California, the need for comparing travel survey methods was identified as a critical research problem. This study constitutes a preliminary first-cut effort at performing such a comparison.

As the array of travel survey methods and instrument types has expanded, transportation planners are faced with an ever-increasing number of choices. Planners are faced with the dilemma of choosing between several means of survey administration including computer-aided techniques, self-administered mail out and telephone interviews. In addition, several types of survey instruments are available including diary and non- diary formats, activity vs. trip diaries, and multi-day vs. one-day surveys. The combinations are numerous. However, there is very little information in the transportation literature on the comparative benefits and costs of these methods in terms of cost per respondent, survey response rates, items non-response, response bias, vehicular and non-vehicular trip rates, and ease of data entry/coding. In this regard, this study will draw from other fields of research including market research, psychology, and sociology.

Even though a comparative study of survey designs should ideally be done under controlled conditions (different surveys administered to the same sample in the same context), such an effort would be extremely time consuming and expensive. as such, for this study, information on various travel surveys that have been conducted around the world in the past five years has been collected to facilitate a first-cut preliminary comparison across travel survey methods and designs. Information on response rates, trip rates and costs per respondent have been collected for about 215 household travel surveys representing a diverse mix of methods and designs. The presentation will report on a comparison of these travel surveys and discuss implications for travel survey design in different planning contexts. The analysis in the study will identify aspects and factors of survey design that influence response rates, item non-response, and missing data. The study attempts to develop a predictive model of response rates as a function of various survey design parameters including, but not limited to the length of survey, presence or absence of an incentive, diary or non-diary format, and single-or multi-stage administration.

An Analysis of Discrete Stated Responses to Parking Pricing Based Transportation Control Measures

Arun K. Kuppam and Ram M. Pendyala, University of South Florida

Abstract

The realization that one can no longer build out of congestion while preserving the urban environment has led to an increasing interest in the potential application of transportation control measures (TCM) for curbing travel demand. One such TCM that is being considered by transportation planning agencies around the country is parking pricing where parking prices and/or taxes are imposed in an attempt to encourage travelers (and more specifically, commuters) to consider alternative modes of transportation. However, very little data and information is available on the potential impacts of parking pricing based transportation control measures and the secondary and tertiary impacts in people's travel pattern that they may bring about. As such, there is a need in the transportation planning community for data on how parking pricing based TCM's may impact travel behavior and commuting patterns.

This presentation is aimed at filling this critical planning need by providing an analysis of stated response data collected from a sample of commuters in the Washington, D.C. metropolitan are in 1994. The data collection effort involved the administration of an elaborate activity-based travel survey together with a TCM questionnaire that collected information on how commuters would adapt to parking pricing based TCM's. Hypothetical parking pricing scenarios were presented to the survey respondents and their state adaptions or responses were recorded. In addition, the effects of the state adaptation on their revealed activity -travel patterns brought about by the TCM. The survey sample consists of 656 commutes who responded to two type of parking pricing based TCM's. The first TCM is a pure parking pricing strategy while the second is a parking pricing strategy coupled with an employer-paid commuter voucher that employees could use toward transportation costs.

The presentation will include a description of the survey sample and their stated responses to the parking pricing strategies. Standard multivariate statistical procedures will be used to identify socio-economic, demographic, and travel characteristics that significantly influence the type of response that a commuter is likely to exhibit when faced with a parking pricing based TCM. Based on the descriptive statistical analysis, a discrete choice model of stated response to parking pricing strategies will be estimated to provide a mechanism by which planners can assess the potential impacts of various parking pricing strategies.

Urban areas around the world are having to deal with increasing levels of traffic congestion and vehicular emissions. Economic and environmental constraints associated with building new infrastructure have motivated transportation planners to embrace a series of strategies, termed transportation control measures (TCMs), aimed at curbing vehicular travel demand[1, 2]. One such TCM, commonly referred to as parking pricing, involves the levying of parking charges or taxes in an attempt to encourage travelers to use alternative modes of transportation[3, 4].

Parking pricing may influence travel behavior in several ways. In order to avoid the parking surcharge, travelers may switch to an alternate mode of transportation that does not involve parking such as transit, bicycle, or walk. On the other hand, one may choose to car or van pool to share the parking costs among several passengers thereby reducing the financial impact of the parking pricing scheme. Alternatively, one may visit new destinations (where parking pricing is not prevalent) for pursuing non-work trip purposes even though these destinations are inferior to those visited previously. In addition, behavioral responses such as choosing to telecommute, changing work or home locations, and parking in alternate locations (resulting in longer walking distances) are also conceivable.

There is very little information about the potential impacts of parking pricing schemes on traveler behavior. Without sufficient data on potential traveler responses to parking pricing strategies, it is virtually impossible to quantitatively predict the impacts of various parking pricing measures on vehicular travel demand. This paper is aimed at filling this critical research need by providing an analysis of stated response data collected from a sample of commuters in the Washington, D.C. metropolitan area in 1994. The data collection effort involved the administration of an elaborate activity-based travel survey together with a TCM response questionnaire that collected information on how commuters might adapt in the event of a parking pricing implementation. Hypothetical parking pricing scenarios were presented to the survey respondents and their stated adaptations or responses were recorded.

This paper provides an exploratory analysis of commuter response to parking pricing that may guide subsequent efforts aimed at developing predictive models of behavior. The distributions of commuter responses cross-classified by selected socio-demographic and travel characteristics are examined to identify those variables that significantly influence commuter behavior in the event of parking pricing. This is followed by a multivariate discriminant analysis that provides a clearer understanding of the combinations of explanatory variables that best distinguish among various response groups.

This paper is organized as follows. Following this introductory section, a description of the data set and survey sample used in this study is provided. The third section provides results of a bivariate descriptive statistical analysis aimed at identifying socio-demographic and travel indicators that are significantly related to commuters' stated response to parking pricing. The fourth section provides results of the discriminant analysis that was conducted to explore relationships in a multivariate statistical framework. Based on the results of the exploratory analysis presented in this paper, conclusions are drawn and directions for further research are outlined in the last section.

Description of Data Set and Survey Sample

The data set used for this study was derived from an elaborate activity-based travel survey that was administered to a random sample of 656 commuters in the Washington, D.C. metropolitan area in 1994[5]. In addition to gathering socio-demographic characteristics and revealed preference activity and travel data, the survey collected stated adaptation data on commuter responses to hypothetical scenarios of six transportation control measures. One of the six measures included in the survey was parking pricing. Respondents were presented with a scenario in which a daily parking surcharge would be levied at their regular workplace. The daily parking surcharge ranged between $1 and $3 per day for suburban work locations and between $3 and $8 per day for downtown and other central Washington, D.C. locations. One parking pricing scenario was presented to each respondent (based on their work location) in an open-ended question format. Their stated adaptation responses were recorded into one of eight possible categories:

- No change in behavior

- Switch to transit mode
- Switch to car/van pool mode
- Switch to bicycle
- Switch to walk
- Work at home
- Change departure time
- Other

The remainder of this section is intended to provide a brief overview of the characteristics of the survey sample. The average household size of the sample of 656 commuters is about 2.7 persons per household, while the average car ownership is about 2 cars per household. An interesting feature of the sample is that auto availability per commuter is quite high with 90 percent of the sample residing in households with one or more cars per commuter. The gender distribution of the sample indicates that 58 percent of the respondents are male. Virtually all of the respondents are licensed to drive. On average, the sample reported a commute (one-way, home-to-work distance) 15.2 miles long and 30 minutes in duration.

Table 1 shows the distribution of commute modes for the sample. The commute mode is assigned based on that used most frequently by a respondent on a weekly basis.

Table 1: Model split for commute trip (n=656)

Commute Mode	Number of Persons	Percentage Share
Drive Alone	458	70%
Transit	66	10%
Car/Van Pool	105	16%
Bike/Walk	20	3%
Other	7	1%

Table 2: Distribution of stated adaptation responses to parking price TCM (n=656)

Response Option	Number of Persons	Percentage Share
No Change	457	70%
Use Transit	72	11%
Use Car/Van Pool	66	10%
Use Bike/Walk	20	3%
Other[a]	41	6%

a. Other includes work at home and change work/home location.

About 70 percent of the respondents usually drive alone to work, 10 percent use bus, rail, or metro, and 16 percent use car or van pool. Only about 3 percent of the sample reported using non-motorized modes for commuting purposes.

Table 2 provides the univariate distribution of stated adaptation responses for the sample of respondents. About 70 percent of the respondents indicated that they would not change their behavior even after the introduction of parking pricing. It should be noted, however, that this includes those who currently use transit, car/van pool, and non-motorized modes of transportation. About one-quarter of the sample responded that they would switch to an alternate mode; as expected, virtually all of these respondents currently drive alone to work. As such, about 34.5 percent of those who usually drive alone to work indicated that they would switch to an alternate mode of transportation in the event of parking pricing implementation.

Comparative Analysis of Stated Adaptation Response Distributions

This section provides a summary of a comparative analysis of different response groups in the survey sample. For purposes of the comparison, four response groups are used:

- No change in behavior

Table 3: Comparison of means across response groups

Variable	TCM Response Group				F-stat
	No Change	Switch to Transit	Switch to Car/Van Pool	Switch to Non-motorized	
No. of commuters	1.7	1.6	1.7	1.6	0.20
Years in current residence[a]	11.6	10.0	7.8	7.9	2.72
No. of vehicles[a]	2.0	1.7	2.0	1.9	1.95
No. of bicycles[a]	1.5	1.0	1.54	1.0	2.28
Current parking charge[a] ($/month)	$9.40	$18.01	$9.42	$1.05	2.25
Commute time[b] (min)	32.5	32.5	29.0	20.6	1.76
No. of days stopped on home-to-work trip[a]	1.29	0.39	1.20	1.25	2.90

a. Significant at 0.05 level
b. Significant at 0.10 level

- Switch to transit
- Switch to car/van pool
- Switch to non-motorized modes (Bicycle and Walk)

As not much is known about the exact nature of the “Other” category, this response group is not included in the analysis.

Table 3 offers a statistical comparison of means of selected socio-demographic variables across response groups. The F-statistic can be used to test the null hypothesis that the means across response groups are equal. If the F-statistic is larger than the critical value at the desired significance level (usually, 0.05), then the means may be considered to be significantly different from one another[6].

It was found that the average number of commuters per household is virtually identical across all the TCM response groups. The F-statistic of 0.20 indicates that the null hypothesis of equality of means can not be rejected. With regard to the number of years that the respondent has resided at the current residence, it was found that the response groups indicating no change in behavior and a potential switch to transit exhibited the longest durations of stay at one location. It appears that a longer stay at one residential location contributes to two potential phenomena. The first one is where commuters are resistant to changing their behavior and will continue habitual behavior despite a change in the transportation environment. The second one is where commuters who have resided at the same location for a long time are more familiar with transit schedules and service reliability that they would feel comfortable shifting to public transportation.

The response group indicating a potential switch to transit exhibited the lowest average vehicle ownership rate. Presumably, these may also be the lower income households who would be most affected, from a financial standpoint, by the imposition of parking pricing. It is interesting to note that this same group also pays, on average, the highest parking charges at their current workplace. As such, this group would be adversely affected by the imposition of an additional parking surcharge over and above what they currently pay.

As expected, it is found that the response group indicating a switch to non-motorized modes of transportation has the lowest average commute time among all groups. Clearly, shorter commute distances are more conducive to the use of such modes. While the groups indicating “no change” and “switch to transit” exhibit identical average commute times at 32.5 minutes, the group that would switch to car/van pool has a slightly lower commute time of about 29 minutes. Interestingly, it is found that the number of bicycles owned by a household does not play a significant role in encouraging a switch to non-motorized modes of transportation. One may conjecture that, while the availability of bicycles is important, it is the commute distance or time that ultimately determines whether a switch to the bicycle mode will be made.

Trip chaining is now widely recognized as an extremely important aspect of travel behavior that has important implications for mode choice, destination choice, and departure time choice for trip making. In order to assess the effect of trip chaining on commuter response to parking pricing, the respondents were asked several questions regarding their usual trip chaining patterns on the way to and from work. In Table 3, the average number of days per week that a commuter stops on the way from home to work (for any trip purpose) is compared across response groups. The most noteworthy finding is that those who indicate a potential switch to transit are those who are the least prone to chain trips to the work trip. While all other groups indicate that they stop on the way from home to work about 1.2 days per week, the group switching to transit exhibits an average of only about 0.4. Trip chaining appears to deter a switch to the transit mode, but does not appear to deter a switch to car/van pool or non-motorized modes of transportation. It is possible that informal car/van pools among household members, co-workers, or neighbors will still allow trip chaining. With regard to those switching to bicycle and walk, it is possible that those trips previously chained to the work trip will now be undertaken in separate trip chains (possibly using the automobile) or made by other household members.

The comparative analysis was further extended to include those socio-demographic and travel indicators that are categorical in nature and for which sample means can not be easily interpreted. Bivariate cross-classification techniques were used to analyze the effects of these variables on parking pricing response distributions. Figures 1 through 8 constitute a set of notable and statistically significant cross-classifications that describe variations in response distributions by different socio-demographic and transportation variables. While there are several other cross-classifications that are also noteworthy and statistically significant, they are not included here for the sake of brevity. The multivariate discriminant analysis presented in the next section sheds light on other socio-demographic and transportation indicators that significantly influence commuter responses to parking pricing.

Figure 1 shows the response distributions by level of parking pricing scenario. As mentioned earlier, the parking pricing scenarios ranged from $1 per day to $8 per day. As expected, it is found that commuters who were presented with low parking pricing scenarios indicated a greater propensity to continue their current behavior. At higher parking pricing levels ($5 and greater), respondents showed a greater propensity to shift to transit. The potential shift to transit is greater than that to car/van pool presumably because those switching to car/van pool would still have to share the parking costs. From the indications provided by this figure, it appears that the stated response questionnaire provided plausible and useful data suitable for TCM analysis.

Figure 1
Distribution by Level of Parking Tax

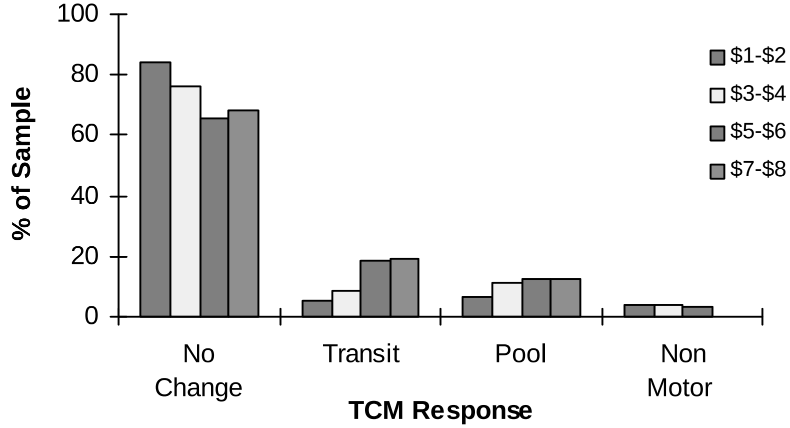

Figure 2
Distribution by Age Category

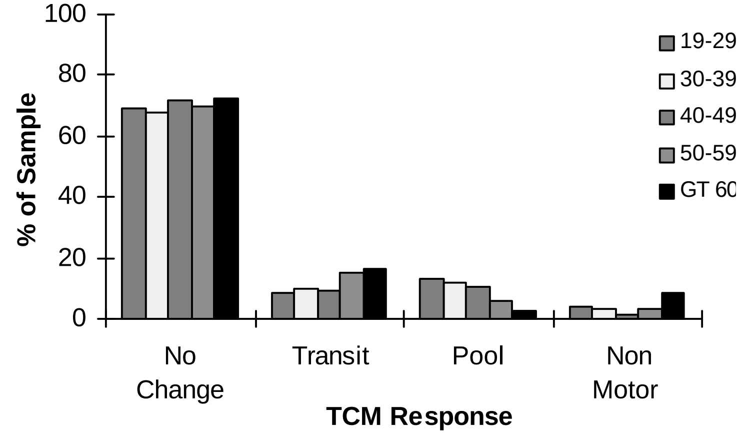

Figure 3
Distribution by Residence Type

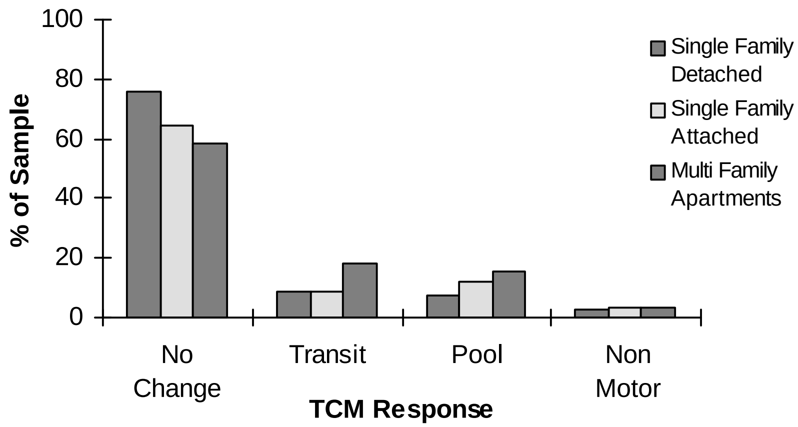

Figure 4
Distribution by Income Group

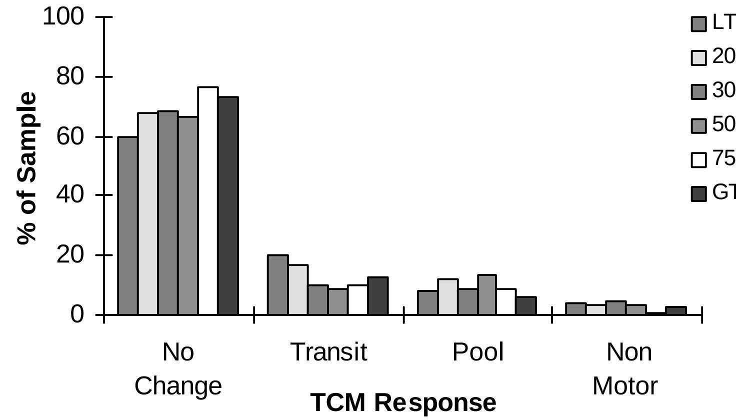

Figure 5
Distribution by Availability of Transit

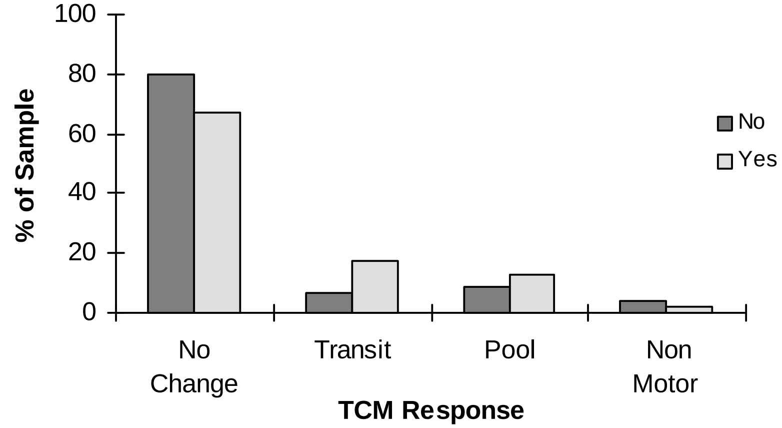

Figure 6
Distribution by Availability of Car/Van Pool

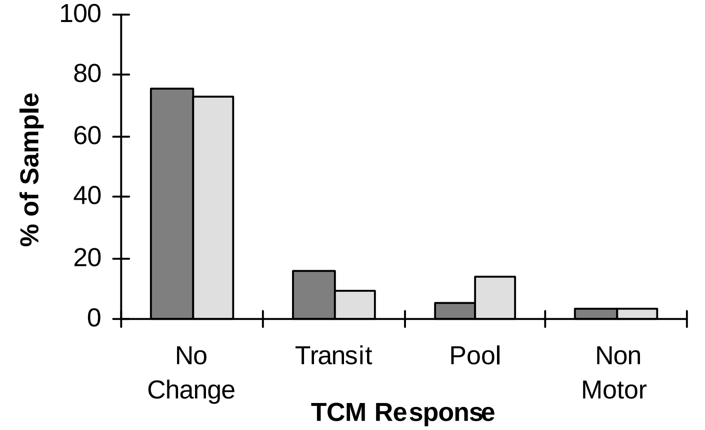

Figure 7
Distribution by Presence of Sidewalk

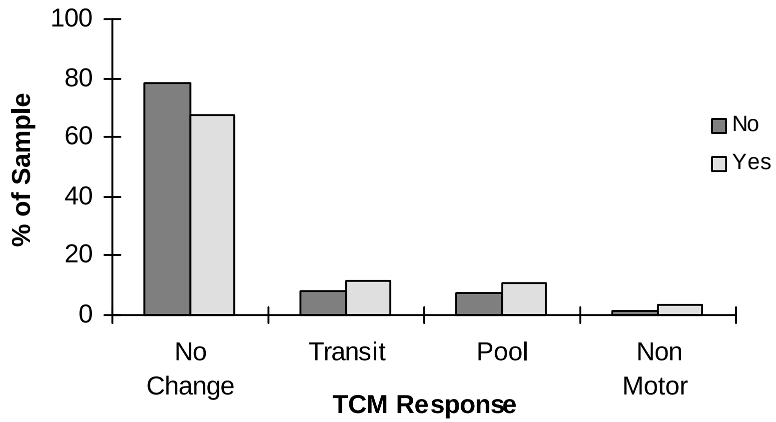

Figure 8
Distribution of Willingness to Pay by Walk Time

Figure 2 examines response distributions by age category. This figure indicates that the percentage of respondents who would not change their behavior is virtually identical across all age groups. However, among those who indicated a propensity to switch modes, it is found that commuters of older age groups (50 years and greater) are more prone to switch to transit while those in lower age groups are more prone to switch to car/van pool. This finding has important implications for transit planners as it appears that there are clear differences in potential transit usage across different market segments.

Figure 3 shows that households residing in single family detached homes are least likely to change commuting behavior. Households in single family detached homes live in suburbs (where transit service is poor), have longer commutes, are of larger household sizes, and belong to higher income categories. As such, their resistance to change is explicable. Figure 4 further confirms that higher income groups are less likely to change behavior. Lower income groups for whom the financial impact of a parking pricing scheme is substantial indicate a greater propensity to switch to transit and non-motorized modes of transportation. Middle income groups are found to choose the car/van pool mode, possibly because they can afford to share parking costs.

Figures 5 and 6 clearly show that alternate modes need to be perceived to be available for people to consider changing behavior. Similarly, the presence of a sidewalk appears to encourage a shift to transit, car/van pool and non-motorized modes (Figure 7). The provision of pedestrian facilities would allow commuters to walk to bus stops, transit stations, car/van pool pick-up locations, and to work, thus making the use of alternate modes more user-friendly.

Finally, Figure 8 shows how commuters trade-off parking costs against walking time. In order to achieve this, two alternatives were presented to survey respondents. First, commuters would pay a parking charge and walk one minute to their final destination or, second, commuters would pay no parking charge and walk 10, 15, or 20 minutes to the final destination. The results yielded very plausible indications. It was found that, as the parking price increases, willingness to pay decreases. Also, within each price category, as walk time increases, willingness to pay increases.

The analysis presented in this section clearly showed that there are several socio-demographic and transportation indicators that are significantly related to commuter responses to parking pricing strategies. Also, the analysis provided very plausible results indicating that the stated response data collected in the survey may be used for further analysis and modeling efforts.

Results of Multivariate Analysis

The analysis presented in the previous section considered the effects of socio-demographic and travel variables on response distributions one at a time. However, for modeling purposes, it is necessary to consider combinations of socio-demographic and travel variables that may explain commuter response to parking pricing. Multivariate discriminant analysis is a statistical procedure that is particularly suited for conducting exploratory investigations prior to undertaking predictive modeling efforts. Discriminant analysis is particularly suited to the analysis of discrete choice variables such as that considered in this study, namely, commuter response to parking pricing scenarios[7].

Discriminant analysis involves the identification of linear combinations of variables that best explain the group membership of sample units. In other words, linear functions of explanatory variables that best distinguish among different response groups are estimated. While the explanatory variables included in the classification functions of different groups are identical, the coefficients associated with these variables may differ. These classification functions can be used to classify new cases whose group membership is not known. Each case is assigned to the response group offering the highest classification function score. Alternatively, classification scores can be used to compute the probability that a case belongs to a certain group using a logit type formulation (6):

$$P_{ij} = \frac{\exp(s_{ij})}{\sum_{k=1}^{g} \exp(s_{ik})}$$

where:

g = Number of groups
s_{ij} = Classification score of case *i* for group *j*
P_{ij} = Posterior probability that case *i* belongs to group *j*

A stepwise discriminant analysis procedure was performed to allow explanatory variables to enter into the discriminant classification functions according to their statistical discriminatory power. The results of the stepwise discriminant analysis corroborated results from the comparative and bivariate analyses presented in the previous section. The variables that were entered into the classification functions include:

- Level of parking tax
- Type of housing unit
- Number of years in current residence
- Gender of respondent
- Age category of respondent
- Availability of car/van pool mode
- Availability of transit service
- Presence of bicycle path
- Number of days per week stopped (for any trip purpose) on way from home-to-work
- Number of days per week stopped (for any trip purpose) on way from work-to-home
- Home-to-work commute time
- Parking charges currently paid by respondent
- Flexibility to leave work early

The results indicated that the level of parking tax imposed is one of the strongest determinants of commuter response to parking pricing. The type of housing unit and the number of years of stay at the same residential location were also significant in explaining group membership. These findings are very consistent with those documented in the previous section. Among socio-demographic variables, the gender and age category of the respondent were found to be significant. In general, females were found to be more resistant to changing their behavior than males, possibly due to reasons dealing with household task allocation and safety. Variables representing the availability of alternative modes were important predictors of group membership. Trip chaining, as evidenced by the number of days that commuters stopped on the way to or from work, was found to deter shifts to alternate modes. As smaller commute times are more conducive to the use of alternative modes, the home-to-work travel time entered into the classification function. Similar to the result reported in the previous section, the parking charges currently paid by the respondent significantly differed across response groups. Finally, it was interesting to note that the flexibility to leave work early was also an important consideration in commuter response to parking pricing. As switching to an alternative mode such as transit or car/van pool may require commuters to leave work early (say, to catch a bus or car pool), it is conceivable that flexible work hours are more conducive to mode switching.

For the sake of brevity, coefficients associated with the discriminatory variables for each response group have not been reported in this paper. The analysis reported here was intended to provide an understanding of the factors influencing commuter response to parking pricing that may help guide future modeling efforts. However, it is to be noted that the discriminant functions may be used in practice within the context of the probability formulation presented earlier to predict traveler response to parking pricing.

Conclusions

This paper reported on the analysis of stated adaptation data to better understand the factors that affect commuter response to parking pricing based transportation control measures. Data from a 1994 activity-based travel survey conducted in the Washington D.C. metropolitan area was used for analysis purposes. A sample of 656 commuters provided stated adaptation information on how they might respond under a hypothetical parking pricing scenario. In general, it was found that about 70 percent of the respondents would not change their behavior, while about 25 percent of the respondents would switch to an alternative mode.

A comparative bivariate analysis and a multivariate discriminant analysis showed that several socio-demographic and travel variables are significantly related to commuter responses to parking pricing. The level of parking pricing, type of household, gender and age of the commuter, availability of alternative modes, trip chaining patterns of the individual, income of the household, and availability of flexible work hours were found to be important predictors of commuter response to parking pricing. In addition, it was found that commuters trade-off walking time against the amount they are willing to pay for parking. Commuters were willing to walk longer distances (park in distant off-site locations) if it would entail lower parking charges.

Ongoing research efforts include the development of discrete choice models of traveler response to parking pricing, examination of secondary and tertiary changes in travel patterns that would result from a mode switch, analysis of the impacts of an employer-paid transportation subsidy, and the estimation of joint revealed preference-stated preference models to better account for the relationships between revealed travel patterns and stated adaptation responses.

Acknowledgment

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Land-Based Classification Standards Update

Jerry Everett, Federal Highway Administration

Abstract

The Federal Highway Administration — along with HUD, FAA, BTS and DOD — has entered into a three- year cooperative agreement with the American Planning Association (APA) to develop an enhanced Land- Based Classification/Coding System. Unlike the 1965 Standard Land Use Coding Manual, the new system will be broadened to cover three categories; land-use information related to the existing built environment, land-cover information related to the natural environment, and land-rights information related to fee/less- than-fee ownership and development rights.

The principal purpose of the project is to ensure that a broad variety of land-based data now being collected and stored at the local, regional, state, and national levels in a variety of formats and classification systems be standardized so that such data would be compatible and, thus, easily transferable between jurisdictions, agencies, and institutions. while the use of such a revamped system would be voluntary, potential users would be strongly inclined to embrace such a system because it would increase opportunities for reciprocal data sharing, both horizontally, form geographic area to geographic area, and vertically, between local, regional, state, and national jurisdictions. In addition, the new and revised classification system will broaden the subject matter of the original 1965 Standard Land Use Coding Manual (SLUCM), which addressed only matters pertaining to land use. Presently, practitioners are collecting, storing, and manipulating three broad categories of land-based information: (a) land-cover information related primarily to the existing natural environment; (b) land-use information related primarily to the existing built environment; and (c) land-rights information related primarily to fee and less-than-fee ownership and to development rights, such as those prescribed zoning and other regulatory measures.

This presentation would be designed to provide the conference participants with an opportunity to hear progress-to-date from the project sponsor as well as to provide input into the standards development process.

Analysis of Stated Preference Survey Data for River-crossing Travel Behavior in the Portland/Vancouver Metropolitan Area

Shinwon Kim, Southwest Washington Regional Transportation Council

Abstract

The MPO in the Southwest Washington and Oregon initiated a major activity and travel behavior survey from the Spring of 1994 to the Fall 1994, including the Stated Preference survey for river-crossing trip behavior. The purpose of the survey is to gain an in-depth understanding of the activities and travel behavior of households as well as individuals within the households in order to build an activity-based travel behavior model.

Southwest Washington Regional Transportation Council (RTC) as an MPO in the Southwest Washington region is using Metro's Travel Forecasting Model as a part of mutual efforts to keep regional consistency in travel forecasting process. Currently, the travel model seems unable to explain the river-crossing travel pattern and demand between the Vancouver area and the Portland area, where two areas are located in two different states and accessed only by two interstate freeway bridges. As an example, the travel model overestimates the home-based work trips by 40 to 50 percent, while it underestimates the home-based other and non-home-based non-work trips especially from the Vancouver area to Portland CBD by 30 to 200 percent, which forces us to use the significant K-factors in calibration. In this situation, it is necessary to explore residents' travel behavior beyond the framework which the conventional travel model can handle. The State Preference methodology is applied to this analysis to identify factors or attributes to affect the residents of the Vancouver/Portland are in their river-crossing trip decision process. Although the Portland/ Vancouver area in the same metropolitan area, there are many differences between the two areas in tax structures, social and cultural aspects.

In developing the Stated Preference Survey, the experimental orthogonal design methodology was used. Attributes considered in this analysis are property tax, state income tax, sales tax, vehicle registration, property value, rent, school quality, travel time, tool, shopping opportunities, specialty stores, restaurant, and special attractions.

The Stated Preference Survey was completed with the 378 respondents in the Vancouver area and the 150 respondents in the Portland area. These sample households were selected from those who completed the Revealed Preference Survey. In this analysis, the discrete data conjoint method is used in developing the multinomial logit model with a fractional factorial experimental design to estimate elasticity of varying levels of attributes.

Vancouver, USA, is located in the southwest of Washington State and is a part of the Portland/ Vancouver metropolitan area. Two Interstate bridges cross the Columbia River and connect the Washington and Oregon parts of the metropolitan area. The bridges are currently showing severe congestion during AM and PM peak periods and carry 232,000 average weekday vehicles. Between the two states, there are substantial differences in tax structures, activity opportunities, living amenities, and other factors (Table 1). Housing prices had been lower in Vancouver, but they are now comparable. Property tax used to be much higher in Portland, but

Background of Stated Preference Methods

Stated preference (SP) methods were originally developed in marketing research in the early

Table 1: Current differences between Portland and Vancouver area

Attributes	Portland Area	Vancouver Area
Property Tax	Avg. $20 per $1,000 value	Avg. $15 per $1,000 value
State Income Tax	9%	None
Sales Tax	None	7.6%
Vehicle Registration Fee	$50 per 2 years	3% of the car value per 1 year
Property Value	Comparable	Comparable
Monthly Rental Rate for 2 bed room	Avg. $537	Avg. $507
Shopping & Recreation Opportunities	More	Less

1970s, known as "Conjoint analysis," "Functional measurement," and "Trade-off analysis" (Kroes and Sheldon 1988). In transportation research, conjoint analysis has been variously referred to as "direct utility assessment" (Lerman and Louviere, 1978), "functional analysis" (Benjamin and Sen, 1983), and "stated preference analysis" (Ministry of Transport and Public Works, the Netherlands, 1985).

Behavioral foundations of conjoint analysis include Lancaster's consumer theory (Lancaster, K. 1966), behavioral decision theory in psychology, known as Information Integration Theory (IIT) (Anderson 1970) or Social Judgement Theory (Brunswick 1952; Hammond 1955), and random utility theory (Thurstone 1927; McFadden 1974; Manski 1977). The approach used here relies on newly emerged paradigms (Louviere and Woodworth 1983) based on random utility theory, discrete or qualitative responses and discrete multivariate statistical analysis techniques.

SP Analysis Procedures

1. Identifying Attributes and Response Choices

Differences between two states in tax structures, amenity, shopping and recreation opportunities, and river-crossing travel conditions were considered as attributes affecting respondents' location choice behavior (Table 2.). Behavioral response choices were defined as location choices for residence, work, shopping, and social-recreation, and as mode choices for work, shopping, and social-recreation purpose. With given conditions described by combinations of attributes for two areas, respondents were to choose one of three locations (Portland, Vancouver, and outside) and one of five modes (drive alone, carpool, regular bus, express bus, and light rail).

Attributes and levels were defined to represent the relevant range of variation to be observed in daily life. These were identified through discussion of issues in a series of focus group meetings, which consisted of ten to fifteen recruited participants. Eligibility for the focus group was specified and used for recruiting sample respondents, such as age (18 years or older), head of household, representative income group, age group, occupations, residency, etc. Findings of the focus group meetings are critical in defining significant attributes and ranges of levels to be varied for the analysis.

2. Choice Experiments

The discrete choice conjoint experiment was designed by Anderson and Louviere based on nine

Table 2: Attributes and levels for Vancouver/Portland Metropolitan area conditions

Attributes	Portland Area	Vancouver Area
Property Tax	\$1500, \$2000, \$2500	\$1000, \$1500, \$2000
State Income Tax	9, 14, 18%	0, 5, 10%
Sales Tax	0, 4, 8%	8, 12, 16%
Vehicle Reg. Fee	\$50 / 2 yr., \$200 / 2 yr., \$300 / 2 yr.	\$30 per \$1000, \$40 per \$1000, \$50 per \$1000
Property Value Increase	no change, 30%, 60%	No change, 30%, 60%
Monthly Rent (for a 2 bedroom)	No change, +\$150, +\$300	no change, +\$150, +\$300
School Quality (average class size)	20-25, 30-35, 40-45	20-25, 30-35, 40-45
Travel Time (one way)	no change, +20 min., +40 min.	No change, +20 min., +40 min.
Toll for 2-way	no change \$3 for peak \$2 for off-peak \$6 for peak \$4 for off-peak	no change \$3 for peak \$2 for off-peak \$6 for peak \$4 for off-peak
Shopping Opportunities	no change, significant increase	No change, significant increase
Specialty Stores	no change, significant increase	No change, significant increase
Restaurant/Evening Entertainment	no change, significant increase	No change, significant increase
Special Attractions	no change, significant increase	No change, significant increase

three-level and four two-level attributes. The total number of profiles is to be set by the number of possible attribute level combinations, so called factorial designs or factorial combinations of attribute levels, which yields a huge number, 3^9 x 2^4, in this case. It would be impossible for respondents to evaluate a huge number of profiles. In this analysis, a smallest orthogonal fractional factorial design of 6^1x3^{24} was chosen. The six-level was used for blocking of profiles, which creates six statistically balanced groups of profiles. Nine degrees of freedom for nine 3-level attributes were used for each alternative and the rest were assigned to four 2-level attributes by collapsing three levels to two levels with the proper coding in orthogonal. From the smallest fractional factorial design of 6 x 3^{24}, there are 54 (=1+5+2x24) degrees of freedom available, which means the least total number of profiles would be 54. Therefore, each block had a set of nine profiles, which each randomly chosen respondent is to evaluate.

3. Survey Form Design and Conduct Survey

The whole survey form package mailed to each respondent included preamble as an introduction to explain the meaning of the survey, a pull-out section of key terminology, survey instructions with examples, and the actual survey questionnaire, so called “SP mockup.” The SP mockup design was important so that respondents could understand clearly and be attracted naturally to the visually well-designed mockups. In this survey, each page of a mockup set (total 54 sheets) carried each profile as a table in landscape format (Table 3.). Each respondent received nine sheets of a mockup set and evaluated different combinations of levels for Portland and Vancouver conditions nine times. Respondents were recruited randomly among those who already completed the activity diary survey. The SP survey was a mail-out and telephone retrieval survey with an

Table 3: SP mockup

Table: 1 Version: 1

Changes In Urban Conditions	Future Portland Situation	Future Vancouver Situation
Property taxes	$2,500 per $100,000 value	$2,000 per $100,000 value
State income tax	14%	10%
Sales taxes	0%	12%
Vehicle registration fee	$50 every 2 years for any car	$30 per $1,000 car value per year
Property value increase	No change	no change
Monthly rental rate (for a 2 bed room unit)	$300 more/month	no change
School quality	average class size 30-35	average class size 30-35
Travel time one way between Portland and Vancouver	Additional 20 minutes	additional 20 minutes
Toll for round trips between Portland and Vancouver	$3 for peak & $2 for off-peak	$3 for peak & $2 for off-peak
Shopping opportunities	Significant increase	significant increase
Specialty stores	Significant increase	significant increase
Restaurants/Evening entertainment	Significant increase	significant increase
Special attractions	Significant increase	significant increase

For each of the following questions, CHECK ONE BOX ONLY.

Given the above conditions, Where would you…	Portland Metro Area	Vancouver Metro Area	Outside of Portland & Vancouver
11a. choose to live?	1❑	2❑	3❑
11b. choose to work?	1❑	2❑	3❑
11c. primarily choose to shop?	1❑	2❑	3❑
11d. primarily go for recreation?	1❑	2❑	3❑

average retrieval time of less than five minutes. The overall response rate was 52.3 percent. The sample size was 378 for the Vancouver area and 151 for Portland area (Nustats, Inc. 1995).

Analysis of the Stated Preference Survey Data

1. Model

Multinomial logit models (MNL) as probabilistic discrete choice models based on random utility theory are used to explore the impact of explanatory attributes on location choices from the fractional factorial orthogonal experiments. The probability to choose an alternative can be estimated by MNL models, where the coefficients of attributes are the marginal probabilities and can be estimated directly and independently of one another. In this location choice analysis, the "no-choice" option was included as a choice of place other than Portland or Vancouver (Louviere 1988). Interaction and cross effects were not significant throughout the location choice analyses.

In this analysis, the main effects were estimated by conditional logit choice models.

Location choices are affected by the perceived influence of four sets of attributes; 1) tax structures (property tax, income tax, sales tax, vehicle registration fees), 2) amenities (property value, monthly rents, school quality), 3) river-crossing travel conditions (travel time and tolls), and 4) others (shopping and recreation opportunities). The perceived influence can be represented by a utility function for each alternative. By repeated measures designs (Louviere 1988), the mean variations of response log odds ratios were examined and led to an additive utility function for the residential location choices.

The observed influence and unobserved influence can be expressed as followings.

$$V_j = \alpha_j + \Sigma\, \beta_{jk}\, X_{jk}$$

where

j = location choice of Portland, Vancouver, other and k = k^{th} attribute,
a_j = alternative-specific constant for alternative j
b_{jk} = alternative specific coefficient for j alternative k^{th} attribute
X_{jk} = k^{th} attribute level associated with alternative j.

$$U_j = V_j + \varepsilon_j$$

where

V_j = observed influence, and
e = unobserved influence (random error).

The probability for alternative j to be chosen can be estimated by the random utility maximization rule.

$$\text{Prob (j)} = \exp(U_j) / \Sigma \exp(U_j);$$
$$\text{Prob(j)} = \text{Prob}\{(V_j + \varepsilon_j) \geq (V_l + \varepsilon_l);\ j \neq l\}$$

2. Residential Location Choice Analysis

The income tax attribute was the most significant impact in location choice. Property tax and sales tax attributes were also strong and significant (Table 4.). The vehicle registration fee attribute was not significant for either area or for both sets of respondents. Respondents were less sensitive to the vehicle registration fee levels than to other tax attribute levels.

The school quality attribute expressed in student/teacher ratio, had a strong impact among amenity attributes. Both Portland and Vancouver respondents were strongly sensitive to levels of the school quality attribute. It was clear that both sets of respondents would not like crowded school conditions. This result may suggest that school quality could be an important factor in the residential land use allocation process. The monthly rent attribute was significant for only Vancouver respondents' evaluation of the Vancouver area. Respondents were not sensitive to different levels of the property value attribute in the two areas, because the two areas have very comparable property value and may be perceived not to have different property values.

Travel related attributes were not significant in residential location choice, though the toll attribute was close to statistical significance for Portland respondents' evaluation of the Vancou-

Table 4: Coefficients for residential location choices

	Portland Respondents			Vancouver Respondents		
Observation	4077 (151 hh)			10206 (378 hh)		
Chi2(28)	383.45			1806.21		
Prob>chi2	0			0		
Pseudo R2	0.1285			0.2416		
Log Likelihood	-1300.1921			-2834.3729		
	Coef.	Z	P>|z|	Coef.	Z	P>|z|
Property tax_p	-0.1015339	-1.497	0.134	-0.2515861	-2.887	0.004
Income tax_p	-0.1979535	-2.916	0.004	-0.5036089	-5.594	0.000
Sales tax_p	-0.1762814	-2.588	0.010	-0.2502334	-2.815	0.005
Veh. Reg. Fee_p	-0.0420212	-0.618	0.536	-0.0622429	-0.695	0.487
Property value_p	-0.0453235	-0.667	0.505	-0.0504305	-0.588	0.556
Monthly rent_p	-0.0738651	-1.090	0.276	-0.0733969	-0.844	0.398
School quality_p	-0.1868449	-2.756	0.006	-0.3135825	-3.557	0.000
River-crossing time_p	-0.0214277	-0.316	0.752	-0.0554377	-0.647	0.518
River-crossing toll_p	-0.0035629	-0.053	0.958	-0.0432492	0.490	0.624
Shopping_p	-0.0306891	-0.255	0.799	-0.0048114	-0.031	0.975
Specialty store_p	-0.0411595	-0.341	0.733	0.1346608	0.840	0.401
Dining/entertain_p	-0.0710871	-0.591	0.555	-0.1377608	-0.913	0.361
Special event_p	-0.0169334	-0.141	0.888	0.1637652	1.084	0.278
Constant_Portland	1.37151	5.073	0.000	-0.2412511	-0.829	0.407
Property tax_v	-0.3177785	-3.189	0.001	-0.1644313	-3.759	0.000
Income tax_v	-0.4415691	-4.366	0.000	-0.2440348	-5.572	0.000
Sales tax_v	-0.1230158	-1.229	0.219	-0.1155582	-2.644	0.008
Veh. Reg. Fee_v	0.0561304	0.565	0.572	-0.0471399	-1.077	0.281
Property value_v	-0.1181811	-1.178	0.239	-0.0706662	-1.616	0.106
Monthly rent_v	-0.1711912	-1.718	0.086	-0.0989602	-2.262	0.024
School quality_v	-0.2376837	-2.366	0.018	-0.1989496	-4.548	0.000
River-crossing time_v	0.0546177	0.551	0.582	-0.0728323	-1.668	0.095
River-crossing toll_v	-0.1772368	-1.782	0.075	-0.0193219	-0.443	0.658
Shopping_v	-0.0132052	-0.075	0.940	0.0027880	0.036	0.971
Specialty store_v	0.0121207	0.069	0.945	-0.0114291	-0.148	0.882
Dining/entertain_v	-0.0129173	-0.074	0.941	-0.0070650	-0.092	0.927
Special event_v	0.1022627	0.582	0.561	-0.0180721	-0.235	0.814
Constant_Vancouver	0.4279702	1.118	0.264	1.6955060	12.700	0.000

Note: ---tax_p: attributes for Portland conditions, ---tax_v: for Vancouver Conditions ver area. When Portland respondents evaluate Portland or when Vancouver respondents evaluate Vancouver, the river-crossing travel time and tolls may not be relevant in their decision. None of shopping and recreation attributes was significant. Significant increase in specialty store and special events in Portland was appealing factors for Vancouver respondents, while increase in those in Vancouver was appealing factor for Portland residents.

Willingness of Vancouver respondents to choose the Portland area for residence was much lower than that of Portland respondents to choose the Vancouver area. Consequently, the willingness of Portland respondents to move to Vancouver is higher than that of Vancouver residents to move to Portland. Vancouver respondents are more willing to stay in Vancouver as well than Portland respondents.

Currently, Oregon has state income tax for those who reside and work in Oregon as well as for those who work in Oregon and reside elsewhere. Washington has sales tax for those who reside and buy something in Washington, but Oregon residents are exempt. Respondents in two areas have different experience with sales tax and state income tax. Consequently, Vancouver respondents responded to levels of the state income tax and sales tax attributes differently from Portland respondents. For Portland respondents, the impact of sales tax in evaluating Portland or Vancouver was very comparable, while the impact of income tax in evaluating Vancouver was more severe than in evaluating Portland. For Vancouver respondents, the impact of both state income tax and sales tax in evaluating Portland was stronger than in evaluating Vancouver by about two times.

The SP models for residential location choices predict the probabilities of Portland or Vancouver residents to choose their residential locations according to changes in state income tax and sales tax (Table 5). By income tax changes in Washington, Portland respondents are much more likely to choose Portland than other place, as their probabilities to choose Vancouver decrease substantially. Vancouver respondents are more likely to move out to Portland and other places. Those who work in Washington and reside in Oregon are still subject to Oregon income tax and have some incentive to move to Washington. But, some Portlanders seem to be attached to Portland and stay in Portland in spite of the burden of Oregon income tax. If Washington had income tax, Portlanders would stay in Portland.

With sales tax changes in Oregon, Portland respondents are likely to move to Vancouver slightly more than to Other Place. The probabilities of Vancouver respondents to choose Portland decrease, as the probabilities to choose other place slightly increase (Table 6.).

Table 5: Residential location choice probability variations by income tax changes in Washington

	Income Tax Changes	Portland	Vancouver	Other	Total
Portland Respondent Choices	Current Situations	60.9%	23.7%	15.4%	100%
	5% Income Tax in WA	66.5%	16.6%	16.9%	100%
	10% Income Tax in WA	70.7%	11.4%	17.9%	100%
Vancouver Respondent Choice	Current Situations	10.9%	75.3%	13.8%	100%
	5% Income Tax in WA	13.0%	70.5%	16.5%	100%
	10% Income Tax in WA	15.3%	65.2%	19.5%	100%

Table 6: Residential choice probability variations by sales tax changes in Oregon

	Sales Tax Changes	Portland	Vancouver	Other	Total
Portland Respondent Choices	Current Situations	60.9%	23.7%	15.4%	100%
	4% Sales Tax in OR	56.6%	26.3%	17.1%	100%
	8% Sales Tax in OR	52.2%	28.9%	18.9%	100%
Vancouver Respondents Choice	Current Situations	10.9%	75.3%	13.8%	100%
	4% Sales Tax in OR	8.7%	77.2%	14.1%	100%
	8% Sales Tax in OR	6.9%	78.7%	14.4%	100%

3. Shopping Location Choice Analysis

The sales tax attribute was only significant and a relevant factor to shopping location choice among tax attributes (Table 7.). Currently Oregon residents are not subject to sales tax in Washington, when they buy something in Vancouver. For Portland respondents, the impact of sales tax in evaluating Vancouver was more severe than in evaluating Portland. Portland respondents seemed to really dislike sales tax in Vancouver, more than Vancouver respondents. For Vancou-

Table 7: Shopping location choice

	Portland Respondents			Vancouver Respondents		
Observation	4077 (151 hh)			10206 (378 hh)		
Chi2(10)	829.88			924.69		
Prob>chi2	0.0000			0.0000		
Pseudo R2	0.2780			0.1237		
Log Likelihood	-1077.6704			-3275.1330		
	Coef.	Z	P>|z|	Coef.	Z	P>|z|
Sales tax_p	-0.1734285	-2.380	0.017	-0.2941371	-6.671	0.000
River-crossing time_p	-0.0631361	-0.867	0.386	-0.0420728	-0.958	0.338
River-crossing toll_p	0.0280335	0.387	0.699	-0.0868363	-1.976	0.048
Shopping_p	0.0220346	0.171	0.864	-0.0073318	-0.089	0.929
Specialty store_p	0.0344248	0.266	0.790	-0.0174748	-0.213	0.831
Constant_Portland	1.367873	6.991	0.000	1.504495	12.301	0.000
Sales tax_v	-0.4656589	-3.892	0.000	-0.3981494	-9.238	0.000
River-crossing time_v	0.0098670	0.085	0.932	-0.0308113	-0.723	0.470
River-crossing toll_v	-0.1684838	-1.453	0.146	0.0533157	1.247	0.212
Shopping_v	0.2339661	1.103	0.270	0.2038771	2.540	0.011
Specialty store_v	0.1937558	0.993	0.361	0.0628038	0.781	0.435
Constant_Vancouver	-0.5480905	-1.902	0.057	1.511748	12.811	0.000

Table 8: Shopping location choice probability variations by sales tax changes in Oregon

	Sales Tax Changes	Portland	Vancouver	Other	Total
Portland Respondents Choice	Current Situations	71.3%	10.5%	18.2%	100%
	4% Sales Tax in OR	67.7%	11.8%	20.5%	100%
	8% Sales Tax in OR	63.7%	13.3%	23.0%	100%
Vancouver Respondents Choice	Current Situations	44.8%	45.2%	10.0%	100%
	4% Sales Tax in OR	37.7%	51.0%	11.3%	100%
	8% Sales Tax in OR	31.1%	56.5%	12.4%	100%

ver respondents, the impact of sales tax in evaluating Portland or Vancouver was strong. Vancouver respondents seemed to dislike sales tax in Oregon more than Portland respondents.

Two attributes related to river-crossing travel, river-crossing travel time and tolls, were not statistically significant overall except “river-crossing tolls” in case of Vancouver respondents’ evaluation of Portland. When Portland respondents consider Portland or when Vancouver respondents consider Vancouver for shopping places, the river-crossing travel time and tolls may not be relevant factors in their decision.

Significant increase in shopping opportunities in Vancouver was an appealing and important factor for Vancouver respondents. For Portland respondents, significant increase in shopping and specialty store opportunities in Vancouver was statistically significant and strong. Respondents in both areas value highly the increase in shopping and specialty stores in Vancouver. Overall, Portland respondents showed strong willingness to stay in Portland for shopping, while Vancouver respondents were likely to go to Portland as much as to stay in Vancouver for shopping.

The SP models for shopping location choice predict Vancouver residents’ probability to choose Portland for shopping according to changes in Oregon sales tax (Table 8.). The four-percent sales tax in Oregon decreases the Vancouver residents’ probability to choose Portland by sixteen percent (from 44.8% to 37.7%), while the eight-percent sales tax in Oregon decrease it by thirty one percent (from 44.8% to 31.1%). Portland respondents are likely to go somewhere else for shopping rather than to Vancouver when Oregon had a sales tax. Vancouver respondents are likely to stay in Vancouver for shopping, but still likely to shop in Portland with more than thirty percent chance, when Oregon has sales tax as much as Washington currently has. Although Oregon had sales tax, Vancouver residents would perceive much richer retail arrays in Portland than in Vancouver and still would shop in Portland.

Conclusions

The analysis examined the impact of explanatory attributes including two travel-related attributes on respondents’ location choices. Two attributes related to river-crossing travel, such as “river-crossing travel time” and “river-crossing tolls,” were found to be statistically insignificant in this analysis. In this unique geographical situation, both residents have only limited access by two interstate bridges in their river-crossing decisions. Also, these two attributes seem relevant to respondents’ river-crossing location choices. Consequently, other location specific explanatory attributes showed much stronger impact in respondents’ location choice decisions. Another transportation-related attribute grouped as one of tax attributes, “vehicle registration fee,” was also generally not significant in this analysis. Both sets of respondents were the least sensitive to levels of the vehicle registration fee among tax attributes in their residential location choice decisions. They seem more tolerant of vehicle registration fee changes among tax changes.

The SP methods used here was an application of newly emerged paradigms based on random utility theory, discrete or qualitative responses and discrete multivariate statistical analysis techniques. Stated Preference analysis can be applied to many types of transportation research and can offer a better understanding of travel behavior. SP analysis is not only a useful tool to measure utilities and marginal probabilities of explanatory variables directly, but also a powerful tool for prediction of travel choice behavior. SP analysis results can support and improve the current travel modeling process.

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Appendix I. Experimental Design Matrix for Location Choice (Six Blocks of Nine Sets Each, Alternative Specific Models, and All Cross Effects Estimable)
by Dr. Donald A. Anderson, StatDesign

b11 0 0 1 2 2 1 1 0 1 1 0 1 1 b11 0 1 2 1 1 0 1 1 0 0 1 1 0
b12 2 2 0 0 1 0 0 0 2 1 0 1 1 b12 2 2 0 2 2 1 0 0 0 0 1 0 1
b13 1 0 2 1 2 1 0 1 2 1 1 1 0 b13 1 0 2 1 1 1 0 0 2 1 1 0 1
b14 0 1 1 2 0 2 0 2 2 0 1 1 1 b14 0 1 1 0 0 1 0 0 1 1 0 0 0
b15 2 0 0 0 2 1 2 2 0 0 1 0 1 b15 2 2 2 1 1 2 2 2 1 1 0 1 1
b16 2 1 0 0 0 2 1 1 1 1 1 1 1 b16 2 2 1 0 0 0 1 1 2 1 1 1 1
b17 0 2 1 2 1 0 2 1 0 1 1 0 1 b17 0 1 0 2 2 2 2 2 2 1 1 1 0
b18 1 1 2 1 0 2 2 0 0 1 0 0 0 b18 1 0 1 0 0 2 2 2 0 0 1 1 1
b19 1 2 2 1 1 0 1 2 1 0 1 1 0 b19 1 0 0 2 2 0 1 1 1 1 0 1 1
b21 1 2 1 0 0 1 1 2 0 1 0 1 1 b21 2 0 1 1 2 2 0 1 2 1 1 0 0
b22 0 1 0 1 2 0 0 2 1 1 0 0 1 b22 1 1 2 2 0 0 2 0 2 1 1 1 1
b23 2 1 2 2 2 0 1 1 0 1 1 1 0 b23 0 2 2 2 0 2 0 1 0 0 0 0 1
b24 1 0 1 0 1 2 0 1 1 1 1 0 1 b24 2 0 0 0 1 0 2 0 0 0 0 1 0
b25 0 0 0 1 1 2 1 0 0 0 1 1 1 b25 1 1 0 0 1 2 0 1 1 1 1 0 1
b26 2 2 2 2 0 1 0 0 1 0 1 0 0 b26 0 2 1 1 2 0 2 0 1 1 1 1 1
b27 2 0 2 2 1 2 2 2 2 1 0 1 0 b27 0 2 0 0 1 1 1 2 2 1 1 1 1
b28 1 1 1 0 2 0 2 0 2 0 1 1 1 b28 2 0 2 2 0 1 1 2 1 1 1 1 0
b29 0 2 0 1 0 1 2 1 2 1 1 1 1 b29 1 1 1 1 2 1 1 2 0 0 0 1 1
b31 2 1 1 1 1 1 1 1 2 0 0 0 0 b31 2 1 2 0 2 2 1 0 0 1 1 1 1
b32 2 2 1 1 2 2 0 0 0 1 1 1 0 b32 2 1 1 2 1 0 0 2 1 1 0 1 1
b33 0 2 2 0 2 2 2 1 1 0 0 1 1 b33 0 0 1 2 1 1 2 1 0 1 1 0 1
b34 1 0 0 2 0 0 0 1 0 0 0 1 1 b34 1 2 0 1 0 0 0 2 0 1 1 1 0
b35 1 1 0 2 1 1 2 0 1 1 1 1 1 b35 1 2 2 0 2 1 2 1 1 1 0 0 0
b36 2 0 1 1 0 0 2 2 1 1 1 1 0 b36 2 1 0 1 0 1 2 1 2 0 1 0 1
b37 1 2 0 2 2 2 1 2 2 1 1 0 1 b37 1 2 1 2 1 2 1 0 2 0 1 1 0
b38 0 1 2 0 1 1 0 2 0 1 1 1 1 b38 0 0 2 0 2 0 0 2 2 0 1 1 1
b39 0 0 2 0 0 0 1 0 2 1 1 0 1 b39 0 0 0 1 0 2 1 0 1 1 0 1 1
b41 2 1 1 2 1 0 1 1 2 0 1 1 1 b41 1 0 1 1 1 0 2 2 2 1 0 0 1
b42 2 2 1 2 2 1 0 0 0 1 1 0 1 b42 1 0 0 0 0 1 1 1 0 1 1 1 1
b43 1 0 0 0 0 2 0 1 0 0 1 0 0 b43 0 1 2 2 2 1 1 1 2 1 0 1 1
b44 0 0 2 1 0 2 1 0 2 1 1 1 1 b44 2 2 2 2 2 0 2 2 0 1 1 0 0
b45 0 1 2 1 1 0 0 2 0 1 0 0 1 b45 2 2 1 1 1 1 1 1 1 0 1 1 0
b46 1 1 0 0 1 0 2 0 1 1 1 1 0 b46 0 1 1 1 1 2 0 0 0 1 1 1 1
b47 2 0 1 2 0 2 2 2 1 1 0 1 1 b47 1 0 2 2 2 2 0 0 1 0 1 1 1
b48 1 2 0 0 2 1 1 2 2 1 0 1 0 b48 0 1 0 0 0 0 2 2 1 0 1 0 1
b49 0 2 2 1 2 1 2 1 1 0 1 1 1 b49 2 2 0 0 0 2 0 0 2 1 0 1 0
b51 2 2 0 1 1 2 0 0 2 1 1 1 1 b51 0 0 2 1 0 2 2 1 2 0 0 1 0
b52 1 2 2 2 1 2 1 2 1 0 1 0 1 b52 2 1 2 1 0 1 0 2 0 1 1 1 1
b53 2 1 0 1 0 1 1 1 1 1 0 0 1 b53 0 0 0 2 1 1 0 2 1 1 1 1 0
b54 1 1 2 2 0 1 2 0 0 1 1 1 1 b54 2 1 0 2 1 0 1 0 2 0 0 0 1
b55 1 0 2 2 2 0 0 1 2 1 0 1 1 b55 2 1 1 0 2 2 2 1 1 1 1 1 1
b56 0 1 1 0 0 1 0 2 2 0 1 1 0 b56 1 2 0 2 1 2 2 1 0 1 1 1 1
b57 2 0 0 1 2 0 2 2 0 0 1 1 1 b57 0 0 1 0 2 0 1 0 0 1 1 0 0
b58 0 2 1 0 1 2 2 1 0 1 0 1 0 b58 1 2 2 1 0 0 1 0 1 1 1 0 1
b59 0 0 1 0 2 0 1 0 1 1 1 0 0 b59 1 2 1 0 2 1 0 2 2 0 0 1 1
b61 0 1 0 2 2 2 0 2 1 1 1 1 0 b61 2 0 0 1 2 2 1 2 0 1 0 0 1
b62 1 1 1 1 2 2 2 0 2 0 0 0 1 b62 0 2 0 1 2 0 0 1 2 1 1 1 1
b63 2 1 2 0 2 2 1 1 0 1 1 1 1 b63 1 1 0 1 2 1 2 0 1 0 1 1 0
b64 2 0 2 0 1 1 2 2 2 1 1 0 1 b64 1 1 1 2 0 0 0 1 0 1 0 1 0
b65 1 0 1 1 1 1 0 1 1 1 1 1 1 b65 0 2 1 2 0 2 1 2 1 0 1 0 1
b66 2 2 2 0 0 0 0 0 1 0 0 1 1 b66 1 1 2 0 1 2 1 2 2 1 1 0 0
b67 0 0 0 2 1 1 1 0 0 0 0 1 0 b67 2 0 1 2 0 1 2 0 2 1 1 1 1
b68 1 2 1 1 0 0 1 2 0 1 1 1 1 b68 0 2 2 0 1 1 2 0 0 1 0 1 1
b69 0 2 0 2 0 0 2 1 2 1 1 0 0 b69 2 0 2 0 1 0 0 1 1 0 1 1 1

* Note: b11, b12 …., b69: fist-version(block) table 1 to sixth version(block) table 9

Appendix II. Creating Choice Data Set

1. Survey Data Format

sample #, Person ID, version #, 5 questions for 9 sets (45 columns choice response data)

2. Convert each row of response data into 9 rows with the same sample # and person ID and version # with table #

sample #, Person ID, 21, 5 columns response data for 5 questions
sample #, Person ID, 22, 5 columns response data for 5 questions
sample #, Person ID, 23, 5 columns response data for 5 questions
sample #, Person ID, 24, 5 columns response data for 5 questions
sample #, Person ID, 25, 5 columns response data for 5 questions
sample #, Person ID, 26, 5 columns response data for 5 questions
sample #, Person ID, 27, 5 columns response data for 5 questions
sample #, Person ID, 28, 5 columns response data for 5 questions
sample #, Person ID, 29, 5 columns response data for 5 questions

3. Create Triplets of Design Matrix for Three Location Choices

21	21.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
21	21.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
21	21.3	13 zero value columns	13 zero value columns (Other area)
22	22.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
22	22.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
22	22.3	13 zero value columns	13 zero value columns (Other area)
23	23.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
23	23.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
23	23.3	13 zero value columns	13 zero value columns (Other area)
24	24.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
24	24.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
24	24.3	13 zero value columns	13 zero value columns (Other area)
25	25.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
25	25.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
25	25.3	13 zero value columns	13 zero value columns (Other area)
26	26.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
26	26.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
26	26.3	13 zero value columns	13 zero value columns (Other area)
27	27.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
27	27.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
27	27.3	13 zero value columns	13 zero value columns (Other area)
28	28.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
28	28.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
28	28.3	13 zero value columns	13 zero value columns (Other area)
29	29.1	Portland Attributes (13 columns)	13 zero value columns (Portland Choice)
29	29.2	13 zero value columns	Vancouver Attributes (13 columns) (Vancouver)
29	29.3	13 zero value columns	13 zero value columns (Other area)

4. Merge Triplets of Design Matrix with Response Data

5. Re-code Choice Responses

Vers #	vers. code	Ptld attributes	Vanc attributes	choice	choice code
31	31.1	13 columns	zero 13 columns	1	1
31	31.2	zero 13 col.	13 columns	1	0
31	31.3	zero 13 col.	zero 13 col.	1	0
32	32.1	13 columns	zero 13 columns	2	0
32	32.2	zero 13 col.	13 columns	2	1
32	32.3	zero 13 col.	zero 13 col.	2	0
33	33.1	13 columns	zero 13 columns	1	1
33	33.2	zero 13 col.	13 columns	1	0
33	33.3	zero 13 col.	zero 13 col.	1	0
34	34.1	13 columns	zero 13 columns	3	0
34	34.2	zero 13 col.	13 columns	3	0
34	34.3	zero 13 col.	zero 13 col.	3	1
35	35.1	13 columns	zero 13 columns	2	0
35	35.2	zero 13 col.	13 columns	2	1
35	35.3	zero 13 col.	zero 13 col.	2	0
36	36.1	13 columns	zero 13 columns	1	1
36	36.2	zero 13 col.	13 columns	1	0
36	36.3	zero 13 col.	zero 13 col.	1	0
37	37.1	13 columns	zero 13 columns	2	0
37	37.2	zero 13 col.	13 columns	2	1
37	37.3	zero 13 col.	zero 13 col.	2	0
38	38.1	13 columns	zero 13 columns	1	1
38	38.2	zero 13 col.	13 columns	1	0
38	38.3	zero 13 col.	zero 13 col.	1	0
39	39.1	13 columns	zero 13 columns	2	0
39	39.2	zero 13 col.	13 columns	2	1
39	39.3	zero 13 col.	zero 13 col.	2	0

6. Conditional Logit Analysis & Results

Does More Information Mean Better Rates? Trip Generation Rates for Selected Special Generators

Dawn McKinstry and Camille Thomason, Parsons Brinckerhoff Quade and Douglas, Inc.

Abstract

The Texas Department of Transportation and Federal Highway Administration, in cooperation with Metropolitan Planning Organizations throughout Texas have been performing comprehensive travel surveys throughout the state since 1990. The surveys included all or a combination of household, employer, truck/taxi, external, on-board and special generators surveys. The last comprehensive survey of special generators was in 1975 in selected urban areas by the state.

The paper investigates the question, is more information better, or can traffic counts suffice? In some locations, a full employee survey and traffic counts were conducted, in comparison to where only a traffic count and employment data were collected The primary generators which are focused on in the paper are military bases, hospitals and universities.

The paper also compares the trip-generation rates for the urban areas of San Antonio, Amarillo, Beaumont and Corpus Christi with the statewide results developed by the Texas State Department of Highways and Public Transportation in 1975. Both geographic and temporal comparisons will be discussed. The Texas experience will be compared with other sources, such as the ITE trip generation manual.

Although particularly relevant to the conducting of special-generator studies, the papers findings will provide information useful to those involved in both computerized and manual traffic impact evaluations and decision making.

Presentation Of Comparative Data for Transportation Planning Studies

Joseph W. Guyton, HNTB Corporation

Abstract

Clear, yet detailed, presentations of transportation planning data to lay groups as well as to technical groups is becoming more and more of a necessity in the planning process. The transportation professional is faced with the challenge of presenting technical analyses in a manner permitting others to make their own, sound, choices. Increasingly, the choice of a preferred alternative involves both technical aspects and seemingly intangibles or quality aspects. Technical analyses often seem to press in one direction while other considerations give a different perspective on the preferred solution.

Peer groups as well as administrators of programs are faced with the need to quickly understand complex planning relationships. Presentation of technical information in understandable terms has become increasingly critical to the decision making process. Professionals develop significant quantitative data to compare and contrast alternatives under investigation, and there is a need to render the results comprehensible for those making recommendations and those making decisions.

Is the oft-used analysis technique of measuring the effectiveness of various alternatives and screening the results becoming inappropriate? Can a process be developed to permit comparisons based on **quantitative** data and on *qualitative* measures? Is there a way to permit individuals to use transportation planning data with *individualized* weightings and judgments to compare alternatives? Can the transportation professional improve the communication channels while maintaining objectivity and comprehensiveness? These are some of the questions which are in need of attention.

Policy statements by FTA and by ITE highlight several approaches to the comparison of alternatives and the selection of measures of effectiveness for those comparisons. This paper addresses the application of simple but effective comparison techniques designed to provide high flexibility to individuals in comparing alternatives.

The presentation of technical results from transportation studies in spreadsheet formats gives the basis for objective comparisons while incorporating the variety of viewpoints on the relative merits of the selected measures of effectiveness. This paper explores the screening techniques used in recent studies for ISTEA High Priority Corridors and feasibility studies and illustrates how the use of a matrix analysis technique has applications in many studies. These approaches were used to assist technical and policy committees in the selection of a preferred corridor. The intent of the paper also is to place the approach in the proper context for various study applications.

Clear, yet detailed, presentations of transportation planning data to lay groups as well as to technical groups is becoming more and more of a necessity in the planning process. The transportation professional is faced with the challenge of presenting technical analyses in a manner permitting others to make their own, sound, choices. Increasingly, the choice of a preferred alternative involves both technical aspects and seemingly intangibles or quality aspects. Technical analyses often seem to press in one direction while other considerations give a different perspective on the preferred solution.

Peer groups as well as administrators of programs are faced with the need to quickly understand complex planning relationships. Presentation of technical information in understandable terms has become increasingly critical to the decision making process. Professionals develop significant quantitative data to compare and contrast alternatives under investigation, and there is a need to render the results comprehensible for those making recommendations and those making decisions.

At times, the technical analyses (on one hand) and (on the other) making the choice of a preferred alternative seem to be at odds with each other. Making a choice with multiple participants and multiple viewpoints can be perplexing. Groups of reviewers see different aspects of a comparison of alternatives, and they can desire many comparisons of the measures of effectiveness or criteria. A comprehensive, objective evaluation needs to illustrate the various viewpoints of many constituents.

The transportation professional is faced with the challenge of presenting technical analyses to various groups in a manner permitting them to make their own decisions. The choice of a preferred alternative involves both quantitative aspects and intangibles or quality aspects. Analyses often seem to press in one direction while new viewpoints and other considerations can give a different perspective on the relative merits of the alternatives.

Presentation of technical information in understandable terms has become increasingly important in transportation studies. Professionals develop significant quantitative data to compare and contrast alternatives under investigation, and there is a need to render the results comprehensible for those making recommendations and those making decisions.

At the same time, there is a need for the professional to produce a fair, objective analysis. Because comparisons involve qualitative and quantitative data, the techniques used to make comparisons need to permit flexibility and adaptation to the various opinions and judgments.

The purposes of this paper are to present screening and comparison techniques used in the evaluation of corridor alternatives, to place one approach in perspective for others to consider, and to present a technique for comparing alternatives that has proven successful in recent endeavors. This paper draws upon case histories in corridor planning and preliminary route location to illustrate the technique, problems, and workable solutions. Recognition is given at this time to the significant contributions in those studies by other consultants and the many state departments of transportation involved.

Objectives

- **Describe an APPROACH for comparing alternatives**
- **Illustrate a matrix comparison PROCEDURE used in corridor studies**
- **Illustrate a PRESENTATION TECHNIQUE for review of complex data**

Although development of the alternatives and their various measures are important elements of any study, this paper is limited to a discussion of the technique for comparing the alternatives. It does not address the development of the alternatives nor development of the data measures. The approach is believed to have applicability to other corridor studies, while recognition is given to the need to adapt the technique to the specific needs of a given project.

Approach for Comparison of Alternative Corridors

There is considerable effort involved in the development of corridor alternatives and the various data descriptors for each. For the purposes of this presentation, those activities are assumed to be acceptably accurate, complete, and comprehensive. The "GIGO" rule still applies-Garbage In, Garbage Out!

Comparisons used to critique alternatives can involve a number of dislike measures, such as travel time saved and disruption of environmentally sensitive areas. The transportation professionals are in need of procedures to permit comparing these alternatives in some meaningful ways. Some procedure to give a ranking of the alternatives within any given measure of effectiveness becomes a necessity in most instances. Reviewers also desire to know how the alternatives might be ranked based on some grouping of the measures. At the same time, caution needs to be exercised to recognize when "double counting" of some measures is involved.[1]

Generally speaking, at least the following characteristics are desired for the procedure:

- Show relativity
- Be consistent in application
- Permit giving more important measures a greater weight or significance
- Be logical
- Be understandable to the participants

The overall approach described herein involves critically comparing a number of alternatives using a series of matrices. The context of the example case studies is a corridor feasibility study. Thus, the purpose of those activities in the case studies was to select the best corridor to use for feasibility analysis purposes. This places a high priority on finding an alternative with reasonably high benefits and low costs. In other applications, detailed consideration would be given to other possibilities, including a "no build" alternative.

The approach for this comparative analysis is to develop a data matrix to compare explicitly the alternatives under consideration. The technique used is such that the criteria measures can be given different weights, can be included or omitted in various comparison groupings, and can be used to rank the alternatives on more than one basis. This can be accomplished by developing several tables (matrixes) after definition of the study criteria and measures of effectiveness.

As applied in a number of recent studies, this technique was used to compare initial corridor alternatives and to make two sets of decisions. One involved a determination of additional corridors to be developed and to be tested. The second involved deciding upon additional measures of effectiveness to be used in the comparisons.

1. Material for this paper was taken from the corridor feasibility studies for ISTEA High Priority Corridor 18 and Corridor 20. HNTB Corporation was one of the key consultants in this work. The Departments of Transportation for the several states involved were Arkansas, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Tennessee, and Texas.

Measures of Effectiveness

Although the development of the criteria and measures of effectiveness is an interesting process, it is too broad a subject to include herein. However, those items used in a recent feasibility study are important to recognize as examples for reference later in this paper. The critique of each study alternative included a comparison of service, impacts, and costs.

Exhibit 1 summarizes some of the measures of effectiveness used in a recent feasibility study. These are grouped within the criteria established during the study for comparing and selecting alternatives. For example, one criteria was to improve traffic service for users of the facility (as compared with existing service), and six measures were selected to compare the alternatives.

The measures need to be good indicators for the criteria involved as well as being items which can be determined for all alternatives. One should also note that some measures can apply to more than one criteria and can lead to "double counting" or multiple counting in the follow-up tabulations.

For example, savings in vehicle operating costs apply to the criteria "improve traffic service for users" and "maximize economic benefits". Another less obvious example relates to minimizing

Exhibit 1: Example measures of effectiveness (corridor feasibility study)

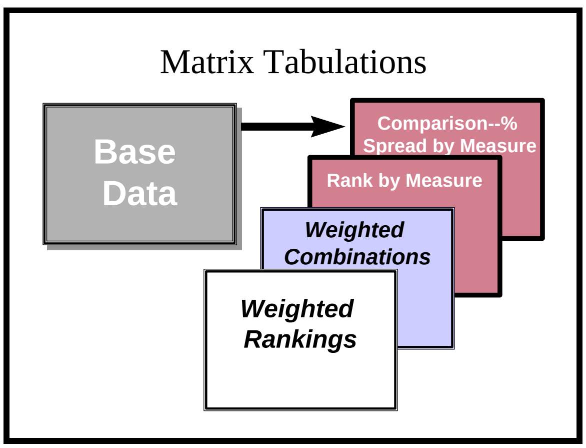
Criteria		Measures of Effectiveness
1. Service Potential	Maximize the population served directly by the study corridor	Population served by the corridor
	Improve traffic service for users of the facility	Vehicle Kilometers of Travel (VKT) along the corridor Savings in vehicle operating costs Savings in travel time Savings in accidents Travel time for the full length of corridor Vehicle Hours of Travel (VHT) on the corridor
	Maximize the traffic relief provided to nearby transportation facilities	VHT within a set study area VKT within a set study area
2. Potential Impacts	Maximize Economic benefits	Jobs added Value added to goods produced Wages added to job payrolls
	Minimize Environmental impacts	Area of wetlands taken for right of way Water areas impacted Area of forest land taken for right of way Area of agriculture taken for right of way Number of sites impacted relative to cemeteries, public parks, National forests, and Superfund sites Length of new loop roads required Length of route required on new rural location
3. Costs	Maximize savings in costs to maintain highways	Highway maintenance costs
	Minimize development costs	Construction costs Right of Way costs Mitigation costs

environmental impacts and costs. A measure for the environmental impact potential is “area of wetlands taken for right of way” while the cost of the wetlands is included in both the mitigation costs and in the construction costs.

Comparisons Using Measures of Effectiveness

Once criteria are designated for selection of a preferred alternative, measures of effectiveness can be established. These need to be ones that can actually be measured to a degree of acceptable accuracy within the study parameters. Once identified, data can be developed for each measure relative to each alternative under study.

The initial step in the comparison of alternatives is to develop a table summarizing the measures of effectiveness as established for each study alternative. Data in one study were grouped into four categories—*socio-economic and environmental, traffic service, costs*, and *feasibility*.



For brevity’s sake, an excerpt of the full matrix of data is used for the remainder of this paper to illustrate the approach. Exhibit 2 presents a portion of the resulting tabulation of data for discussion purposes. Note that additional measures and ratios of measures can be used in the comparisons when deemed appropriate.

One of the first questions to be addressed is, “How do the alternatives “rank” for each measure of effectiveness?” To address this question, the review of each measure for all alternatives can be made easier if the data are placed on a common basis, say showing how each alternative’s measure relates to the maximum value for that measure. For example, what percent of the traffic service provided by the best alternative is there provided by the other alternatives? This can be followed by a ranking of the alternatives, and a comparison for groups of measures.

Four matrix comparisons have been developed in the illustrative studies. The four tables are discussed in the following paragraphs. Excerpts of the four matrix tables are included as Exhibits 3 through 6. In brief, these provide for:

- Calculating the relative values for the alternatives within each measure of effectiveness
- Ranking of alternatives within each measure of effectiveness
- Calculating weighted values for various combinations of the measures of effectiveness
- Ranking of alternatives for combinations and groups of measures of effectiveness.

Initial Comparisons

The first step in the comparison process is to place each set of data for each measure on a common comparison basis. Experience has shown that the use of a percentage of the maximum value in each row (i.e. for each measure) produces a useful indicator and one that often is desired by the

Exhibit 2: Example of raw data matrix (excerpt)

Measure	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Population served by route, millions	2.79	3.01	2.99	3.02	3.22	3.47	3.52
Number jobs added	9,700	9,200	9,500	10,400	11,000	11,900	12,700
Travel Time Savings, millions $	$747	$721	$757	$806	$852	$939	$1,006
Accident Cost Reduction, millions $	$2,315	$2,524	$2,248	$2,567	$2,730	$3,134	$3,247
Total Cost in millions	$3,192	$3,363	$3,359	$3,393	$3,599	$4,337	$4,832
Travel Discounted B/C	1.68	1.66	1.56	1.72	1.72	1.58	1.49

Exhibit 3: Example calculation of the relative values for each measure as a percent of maximum raw data value

Measure	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Population served by route, millions	79%	86%	85%	86%	91%	99%	100%
Number jobs added	76%	72%	75%	82%	87%	94%	100%
Travel Time Savings, millions $	74%	72%	75%	80%	85%	93%	100%
Accident Cost Reduction, millions $	71%	78%	69%	79%	84%	97%	100%
Total Cost in millions	66%	70%	70%	70%	74%	90%	100%
Travel Discounted B/C	98%	97%	91%	100%	100%	92%	87%

Exhibit 4: Example ranking of alternatives within each measure (5=best, 1=least desirable)

Measure	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Population served by route, millions	1.0	2.2	2.1	2.3	3.4	4.7	5.0
Number jobs added	1.6	1.0	1.3	2.4	3.1	4.1	5.0
Travel Time Savings, millions $	1.4	1.0	1.5	2.2	2.8	4.1	5.0
Accident Cost Reduction, millions $	1.3	2.1	1.0	2.3	2.9	4.5	5.0
Total Cost, in millions	5.0	4.6	4.6	4.5	4.0	2.2	1.0
Travel Discounted B/C	4.3	4.0	2.2	5.0	5.0	2.6	1.0

Exhibit 5: Example summation of weighted values

Measure	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
All factors, equal weight, 47 items	139.1	170.6	130.1	184.4	190.2	146.4	120.0
Socio-Economic and Environmental (20 items)	52.0	69.8	48.9	73.3	78.4	64.6	61.6
Socio-Economic and Environmental (15 items)	40.4	51.8	39.2	54.7	57.7	49.1	45.1
Traffic Service (8 items)	20.1	21.7	19.6	24.0	25.4	27.9	24.0
Development Cost (9 items)	34.6	39.5	35.3	40.2	38.9	21.7	14.7
Development Cost (5 items)	21.0	24.2	19.8	23.3	22.6	10.0	6.7
Feasibility (9 items)	27.4	34.7	21.7	42.3	43.3	30.0	18.7

Exhibit 6: Example ranking of alternatives for combinations and groups of measures (5=best, 1=least desirable)

Measure	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
All factors, equal weight (47 items)	2.1	3.9	1.6	4.7	5.0	2.5	1.0
Socio-Economic and Environmental (20 items)	1.4	3.8	1.0	4.3	5.0	3.1	2.7
Socio-Economic and Environmental (15 items)	1.3	3.7	1.0	4.4	5.0	3.1	2.3
Traffic Service (8 items)	1.2	2.0	1.0	3.1	3.8	5.0	3.1
Development Cost (9 items)	4.1	4.9	4.2	5.0	4.8	2.1	1.0
Development Cost (5 items)	4.3	5.0	4.0	4.8	4.6	1.8	1.0
Feasibility (9 items)	2.4	3.6	1.5	4.8	5.0	2.8	1.0

reviewers as well as by the analyst. Many are looking at the raw data and trying to determine which Alternative has the highest number, the lowest, and how the others relate to these extremes.

The first matrix (Exhibit 3) places the comparative data for the seven alternatives on a common base by converting the values for each measure to a percent of the maximum value for all alternatives. In reviewing this matrix, one can readily discern the alternative with the maximum value for each measure (shown as 100%) as well as how compact or close together the measures are for all alternatives.

For example, the highest population served at 3.52 million (Alternative 7) is used as 100%, while Alternative 1 with 2.79 million calculates to be 79% of that value. The least population served (Alternative 1) shows serving only 79% of that served by the best alternative from this single measure.

A reviewer can readily see how closely the measures are grouped or how far apart they are for the alternatives. [Note that Exhibit 3 is an excerpt of the full table developed in the case studies.]

High vs. Low Values, Which Is Best??

- **There are different goals for individual measures. For example,**
  - **Population Served, result desired needs to be HIGH**
  - **Cost to Build, result desired needs to be LOW**

The second matrix (Exhibit 4) then ranks the alternatives (from 5 is best to 1 is least desirable) taking into consideration whether higher values are best or lower values are best. Thus, for the illustration used herein, a value of 5 is always given to the "best" alternative for that measure. The first matrix (Exhibit 4) clearly shows the spread and the grouping of alternatives within a given measure, while the second matrix (Exhibit 5) places all rankings on a common scale, 1 to 5 (or any other range desired).

In the example, for the measure "population served", Alternative 7 is the best of the alternatives and is ranked 5. Alternative 1 has the lowest value and is ranked 1. Each of the other alternatives is pro-rated between 1 and 5 according to its relative value.

Note that in this example, the best Alternative for each criteria measure involved is ranked 5. The least desirable is ranked 1. Others are scaled (pro-rated) between 1 and 5. If several of the alternatives have data that are very close to the "best", they will receive rankings very close to a 5. For example, in looking at the criteria measure for "Total Cost" in Exhibit 4, three alternatives have very close results near the least amount and are ranked 4.6, 4.6, and 4.5.

Combinations of Measures

All reviewers have questions about how the alternatives would be ranked when considering various combinations of the measures. The third matrix (Exhibit 5) presents a series of combinations of measures using data from the previous tables. For example, all 8 of the Traffic Service measures are combined with equal weight given to each measure by summing the rankings from the previous table for each alternative. Alternative 1 receives 20.1 ranking points; Alternative 2, 21.7; etc.

Approach to Ranking in Examples

- **IF value is least desirable, RANK IT 1**
- **IF value is best, RANK IT 5**
- **IF value is in between, pro-rate between 1 and 5**
- **OTHER COMBINATIONS CAN BE USED**

The fourth matrix (Exhibit 6) repeats the ranking procedure (from 5 is best to 1 is least desirable) for the combinations of measures. This process facilitates the comparison of the alternatives by showing for all measures the "best" alternative as a "5". For example, with equal weighting for the 8 Traffic Service measures, Alternative 6 has the highest total at 27.9 points in the third matrix and is considered the best overall. Alternative 3 has the lowest total (19.6) and is considered the least desirable. Each other alternative is ranked on a pro-rata basis between 1 and 5.

Variations in Ranking Procedures

Any of several alternative ranking procedures could be used for Exhibits 4 and 6. For example, ranking from 1 to 10 could be used instead of from 1 to 5, or a "1" could be used as being best instead of least desirable. In developing the combinations, different weights can be given to each measure in order to permit giving different importance to the various measures.

Exhibit 7: Some combinations of measures

Group	Measures Included
A	3 State Economic Impact factors
B	3 Area Economic impact factors
C	2 Benefit Cost ratios (Travel and State)
D	Socio-Eco-Env (SEE) factors + Benefit/Cost Ratio (B/C factors)
E	Savings in Op Cost, Accidents, Travel Time (Savings Factors)
F	Socio-Economic and Environmental (SEE) Factors
G	SEE Factors + Savings factors + Cost/VKT + ADT/km
H	14 Distinguishing Measures
J	SEE + 2 Traffic Service + Travel B/C

Another variation that was explored involves using what some termed a "constant yardstick" when developing the comparisons shown in Exhibit 3, Calculation of the Relative Value for Each Measure as a Percent of the Maximum Raw Data Value. This modified procedure relates each measure to the extremes in the range for all measures rather than to the extremes for each measure.

The tables presented herein

were developed in a spreadsheet format with look-up values for the “best” and “least desirable” ranking numbers to be used. In addition, a separate look-up permits giving the different weights to the individual measures of effectiveness and/or to a set group of measures. For example, each of the measures within the socio-economic impact group can be given individual weights to increase the relative importance of each measure. Or the entire group can be given a weighting different from the other measures or groups of measures.

Exhibit 7 illustrates some of the 45 combinations of measures developed in one recent feasibility study to accommodate questions raised by reviewers and analysts on whether rankings would change if certain measures were deemed more important than others. Some groupings involved multiple counting of specific measures. These groupings are in addition to the examples in Exhibits 5 and 6 and are derived from the specific measures identified in Exhibit 1. In addition, specific groups were further modified to investigate placing more or less importance on specific measures or groups of measures. For example, the effect on rankings of doubling, tripling, etc. the weight given to “Total Cost” was investigated.

Does this technique seem overly complex? Is it simply too involved to comprehend? It has worked well with administrators and with technical (professional) staff. In recent corridor studies the use of this approach has proven very effective in permitting advisory committees to compare the alternatives realistically. For pubic presentations, simplified visual aids were desired to present the essence of the comparisons and rankings while making details available for those desiring more information. The initial step is to provide a clear explanation. Most people seemed to be more interested in having an overview of the process and in making their position clear rather than in dwelling upon the details of the analyses.

Comparison of Alternatives
in Matrix Format

- Base Data for each Alternative with Measures of Effectiveness
- Comparison of Alternatives within each Measure of Effectiveness
- Relative Ranking of Alternatives within each Measure of Effectiveness
- Combinations of Measures
- Weighted Ranking of Alternatives

Conclusions

Different individuals-whether professional or lay persons-often desire to explore the ranking of alternatives in various ways. They can give different importance to some measures of effectiveness (or criteria), or they may simply wonder how rankings might change for different viewpoints on the measures to be considered.

The approach for the comparative analyses presented herein is to develop several data matrices to compare explicitly the alternatives under consideration. The technique used is such that the criteria measures can be given different weights, can be included or omitted in various comparison groupings, and can be used to rank the alternatives on more than one basis.

One caution is to insure adequate reliability of data used in the matrices. Another is to recognize when there is double counting of measures and to insure that reviewers understand the significance of double counting data.

This type of ranking procedure is not a substitute for sound analysis and sound judgment. The calculations do not determine which alternative is the best; they simply present the results of the data *input to the process in a manner facilitating analysis. Poor input yields poor results. If the resulting rankings do not support the most logical and defensible solution, then something is amiss and further evaluation is needed.*

MIS Evaluation Frameworks - A Comparative Analysis

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Abstract

Many major investment studies now being conducted are evaluating a range of multimodal transportation system alternatives. These evaluations must use a variety of cross-modal performance criteria to address project goals and objectives that, in some cases, may not be complementary. Mobility, accessibility, environmental and cost considerations must be evaluated across highway widening or new construction, HOV, local/express bus, light and/or heavy rail, and TSM/TDM alternatives. On top of this, alternative improvements need to be compatible with existing state, MPO and local land use and transportation plans.

Establishment of a comprehensive evaluation framework early in the MIS process has three primary benefits: first, it promotes cost-effectiveness by focusing the study team's efforts on only those analyses that are necessary to address the study's goals and objectives; second, it helps to establish how the evaluation results will be communicated to the public and decision-makers; and third, it compels the various stakeholders to "buy in" to the evaluation process early in the study.

This paper will compare and contrast multimodal evaluation frameworks that have been developed and applied for three major investment studies conducted within the Washington, DC metropolitan area. Initially, a description of the evaluation framework used for the I-270/US 15 Multimodal Corridor Study will be reviewed in the context of the goals, objectives and measures of effectiveness (MOEs) that were established to guide this two-stage MIS. This review will also include a discussion of the interactive process that was used to develop the framework and the issues that arose. Next, the differences and similarities of the I-270/ US 15 Study evaluation framework will be compared to the frameworks used by two other MIS projects, which are similar in scope to the I-270/US 15 Study. The purpose of this comparative analysis will be to identify strengths and weaknesses associated with each evaluation process in order to develop recommendations for multimodal MIS evaluation frameworks.

Symptoms, Diagnoses, and Prescriptions: Evaluating and Improving the Performance of the San Francisco Bay Area's Arterial Roadway Network

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Abstract

Shortly after the passage of ISTEA in late 1991, the Metropolitan Transportation Commission (MTC) assembled the leaders of three dozen federal, state, regional, and local institutions responsible for highways and roadways, transit, seaports and airports, ridesharing and air quality management. Known simply as the Bay Area Partnership, the consortium came together to develop a first-ever transportation system management *strategy*, designed to garner the most efficiency from the region's investments. The resulting network of highways, major arterials, transit services, rail, ports, airports, and transfer hubs critical to the region's movement of people and goods is known as the *Metropolitan Transportation System* (MTS).

MTC is now in the process of assessing the performance of individual components of the MTS and developing strategies to improve them. This paper, which examines the *arterial roadway system*, describes a two-fold *performance evaluation* and *improvement strategy development* process.

Using a wide variety of user- and operator-based performance measures, the performance evaluation of the MTS arterial network will be characterized across five dimensions:

1. *Mobility*, the ability with which both people and goods can move about,
2. *Accessibility*, a function of both land use patterns and the transportation system that serves them,
3. *Connectivity*, the degree of integration of the individual elements of the transportation system,
4. *Safety*, and
5. *Externalities*, i.e. noise and air effects.

Linked to the results of the performance evaluation process will be alternative *improvement strategies* which will provide local traffic managers and engineers with a wide menu of approaches to solving operational problems. This cornerstone project will break new ground for MTC in their effort to balance funding appropriations across geographical and modal boundaries.

MIS Case Study: I-94 Rehabilitation Project - Detroit, Michigan

Gerald H. Martin and Paul Hershkowitz, Michigan DOT; James A. Mauer, Parsons Brinckerhoff Quade & Douglas, Inc.; Janice Frazier, Jay Gregory and Associates; and Charles Dulic, HNTB Michigan, Inc.

Abstract

ISTEA includes specific requirements for inclusion in studies of Major Investment Projects in Metropolitan Planning Areas. The State of Michigan initiated a Major Investment Study (MIS) in October 1994 for the redesign and reconstruction of a 7 mile long section of I-94 from the I-96 (Jeffries) Freeway Interchange easterly to its interchange with Conner Avenue. This section of I-94 serves a number of areas of special importance in Detroit, including the downtown business area, Wayne State University, the New Center, the Cultural Center, the Medical Center, and the City Airport. This section of I-94 is also an integral link in the entire Detroit Freeway System and includes interchanges with the I-96 (Jeffries), M-10 (Lodge), and I-75 Freeways, as well as major Detroit thoroughfares. It must also be emphasized that I-94 carries a high volume of commercial traffic, and constitutes a significant trans-continental and international trade route throughout its entire length.

To achieve consensus building, the MDOT established an Interagency Coordination Committee (ICC) which includes representatives of MDOT, FHWA, FTA, SEMCOG, the City of Detroit, and Wayne and Macomb Counties. This committee is chaired by the MDOT Project Manager and maintains an active role in project decision making. In response to MIS requirements for justifying the addition of general use lanes for improving mobility, the study includes evaluation of potential for Special Use Lanes for the exclusive use of High Occupancy Vehicles (HOV), trucks, or other combined special uses. A great effort is involved in this project in the area of Public Involvement and Public Information, and many avenues of communicating information and receiving public input are being employed.

A very ambitious schedule of 30 months was set for the completion of this study. Maintaining this schedule requires aggressive project management and a firm commitment to remain within the limits of the project scope. The most pressing need for maintaining the project schedule is caused by the advanced state of deterioration of the Dequindre Yard Bridge, requiring its replacement. This is one of the largest bridges in Michigan, carrying I-94 over the Dequindre Rail Yard.

Major issues on this project include: 1.) Balancing the need to proceed quickly with the need for a thorough development and analysis of alternatives for the redesign of the entire study section and conformance to MIS requirements; 2.) Balancing conflicting goals of selecting the best alternative and minimizing displacements; 3.) How great a percentage of the entire MIS effort on a major urban project should be expected to be concerned with public involvement/public information; 4.) Producing recommendations that are specific enough for final design to commence while retaining enough flexibility to meet changing situations that cannot yet be anticipated. The paper will examine these issues and other major study elements, the degree to which they are, or are not, being successfully addressed through the MIS process, and areas for possible improvement of the MIS process.

The present Surface Transportation Act, ISTEA, specifies certain specific requirements for projects that qualify as Major Investments in metropolitan planning areas. The Act also outlines special requirements for Major Investment Studies (MIS) related to these projects.[1]

Very briefly, compliance with MIS requirements requires special attention to at least three main areas. First, major project decisions are to be made by consensus of the involved jurisdictions and the MPO, as well as the State DOT, the Federal Highway Administration (FHWA), and the Federal Transportation Administration (FTA). Second, the study of alternatives must include a complete treatment of alternatives that improves the mobility of people and goods, while alleviating the need for additional general use lanes. Third, the study must include a pro-active public involvement/information program that brings public input into the decision making process as much as possible. The Michigan Department of Transportation (MDOT), already includes these elements in their Early Preliminary Engineering (EPE), or Phase I, studies, because they are required by the National Environmental Protection Act (NEPA) process. ISTEA now requires more far-reaching, and well-articulated efforts in these three areas for MIS projects, than may have been customary in the past to satisfy the NEPA process alone. MIS documentation can be submitted in a separate report to the FHWA, or combined with the Environmental Impact Statement.

The State of Michigan initiated its first MIS Study in October 1994, and it is presently still underway. This project is the redesign and reconstruction of a 7 mile long section of I-94, from the I-96 (Jeffries) Freeway Interchange easterly to its interchange with Connors Avenue, which constitutes a key link in the Greater Detroit Area Freeway System.

The Detroit, Michigan I-94 Project

The Greater Detroit Area Freeway System is a network that includes a number of aging freeway sections, some of which were constructed in the 1950's. Deficiencies on some of these sections have reached a point, beyond the curative powers of maintenance procedures, requiring complete reconstruction. Recognizing this, (MDOT), cooperatively with the Southeast Michigan Council of Governments (SEMCOG) and Wayne County, completed a planning study of the Greater Detroit Area Freeway Network to identify and prioritize freeway sections in most need of improvement. The results of this study identified I-94 as the Detroit area freeway with the highest priority for improvement. The first section of I-94 selected for rehabilitation is the previously identified 7-mile section through Detroit. This section was selected for the initial improvement study because of its location, service functions, and connections with other elements of the freeway network. In order to complete this study in a timely manner, the MDOT has retained the services of a consultant team led by Parsons Brinckerhoff Quade & Douglas, Inc. as the prime firm.[2] The Phase I costs of this study will be in excess of $7 million and ultimate construction costs are expected to approach $1 billion.

This section of I-94 serves a number of areas of special importance in Detroit, including the downtown business area, Wayne State University, the New Center Area, the Cultural Center, the Medical Center, and the City Airport. This section of I-94 is also an integral link in the entire

1. Reference should be made to ISTEA and other related documentation for a complete definition of Major Investment Projects and requirements for Major Investment Studies.
2. Member firms of the consultant team include: Parsons Brinckerhoff Quade and Douglas, Inc.; HNTB Engineering and Architecture, Inc.; Snell Environmental Group, Inc.; Jay Gregory & Associates Consulting; Engineering Associates, Inc.; Great Lakes Research Associates, Inc.; Charlevoix Abstract & Engineering Co.; Cole Financial Services, Inc.; Tucker, Young, Jackson, Tull, Inc.; PR Associates, Inc.; PR Networks, Inc.; and Moore and Associates, Inc.

Detroit Freeway System and includes interchanges with the I-96 (Jeffries), M-10 (Lodge), and I-75 Freeways, as well as major Detroit thoroughfares. It must also be emphasized that I-94 carries a high volume of commercial traffic, and constitutes a significant trans-continental and international trade route throughout its entire length. This multiplicity of function makes this section of I-94 a linchpin of the Detroit Freeway System. Accordingly, the project must include the redesign and reconstruction of the major freeway to freeway interchanges at I-75 and M-10 (Lodge Freeway).

This section of I-94, with the above stated interchanges, provides a connection for commercial and private trans-continental traffic to the two Detroit \ Windsor border crossing facilities. This last point is extremely significant because of the high volume of international trade between the US and Canada, as well as Atlantic Trade at these boarder crossing facilities. The volume of international trade at the Detroit / Windsor border is nearly comparable to the trade at the Mexico / Texas and Mexico / California borders combined. Additionally, I-94 is doubtlessly of service to a substantial volume of Michigan / Mexico trade in Auto Parts and Agricultural Produce.

Traffic analyses to date, has included origin-destination studies, existing traffic counts, and traffic forecasts for the year 2015. The SEMCOG Tranplan Model was used to help with distribution to establish existing traffic patterns, and to provide traffic simulation for forecasting peak period and peak hour volumes. The model predicted a growth in traffic volumes of approximately 20% between 1996 and 2015. The Origin-Destination study indicated that approximately 90 percent of the existing traffic was traveling through the study area while the remaining 10 percent had an origin and/or destination within the areas served by the study section of I-94. It is anticipated that these percentages of trip types could change dramatically in the future with the development of the special interest areas and economic empowerment zones adjacent to the seven mile study section of I-94.

Since this study has begun, the Federal Government has been considering the establishment of a special International Trade Route linking the United States and its two NAFTA Trading Partners, Canada and Mexico. This section of I-94, for reasons outlined above, would form a logical and crucial link in that corridor.

This section of I-94 passes through areas in Detroit that have been declared to be economic empowerment zones. A coordinated effort is being made by the involved units of government, the MPO, and other key interest areas, to ensure that the final design of this section of I-94 is compatible with plans for the economic redevelopment of these zones.

Initially, a very ambitious schedule of 30 months was set for the completion of alternative development, evaluation, and selection, as well as environmental clearance for the redesign of the I-94 Freeway. The attempt to maintain this schedule has required aggressive project management and a firm commitment to remain within the limits of the project scope of work. The major reason for setting this ambitious schedule is the deteriorated condition of the structures included in the I-94 study section. There are approximately 65 bridges over this 7 mile long section of freeway. The most pressing need, however, is the replacement of the Dequindre Yard Bridge. This is one of the largest bridges in Michigan, carrying I-94 over the Dequindre rail yard. Replacing this structure, while adhering to traffic maintenance requirements, will require the realignment of the section of I-94 immediately east of the I-75 Interchange. The advanced state of superstructure deterioration of this structure, and the complicating traffic maintenance requirements of this section, demands a timely completion of the I-94 EPE study so that design of this section can begin. This need to proceed quickly must always be balanced by the need for a thorough development and analysis of alternatives for the redesign of the entire study section of I-94. The option of combining the MIS documentation with the EIS has been adopted for this study.

Project Conformance To MIS Objectives

To achieve consensus building, the MDOT established an Interagency Coordination Committee (ICC) which includes representatives of the MDOT, the FHWA, the FTA, SEMCOG, the City of Detroit, and Wayne, and Macomb Counties. This committee is chaired by the MDOT Project Manager and has enjoyed the direct participation of high ranking decision makers from its member agencies. The purpose of the ICC is to provide project oversight and to reach consensus on major project decisions. This committee remains very active in the project, and convenes on a monthly basis, and more often when issues require. The ICC has reached consensus on the goals and objectives of the study, the public involvement and public information plan, and the range of alternatives to be pursued. The committee has also reviewed input resulting from the public information process.

To satisfy the requirement of examining alternatives to the addition of general use lanes for improving mobility, the study includes an evaluation of potential special use lanes for the exclusive use of High Occupancy Vehicles (HOV), trucks, or other combined special uses. I-94 presently consists of three lanes in each direction. Traffic Studies, counts, Origin-Destination Studies, and traffic demand forecast modeling have indicated a need for four general use lanes in each direction. Therefore, special uses would have to be provided by a fifth lane in each direction. Various alternatives have been considered that would provide for such a cross-section.

A great effort is involved in this project in the area of Public Involvement and Public Information. and many avenues of communicating information and receiving public input are being employed. Approaches being used include well publicized public information meetings, formation of a Citizens Advisory Group, many outreach meetings with neighborhood, focus, and special interest groups, citizen surveys, newsletters, and media news releases and interviews. This project continuous to be a Public involvement success and enjoys a high degree of cooperative involvement of City of Detroit officials, including the Mayor and Deputy Mayor.

Effectiveness Of MIS Related Efforts

The ICC has been successful since its inception. Disagreements are expected, and as they occur, the ICC has learned to deal with them constructively. Varying points of view are articulated and consensus on acceptable solutions are sought. The successful functioning of this committee is paramount to the success of the study. There were issues encountered at the outset of the study relating to contact protocols between the MDOT and Consultant team members with City of Detroit officials, and personnel from City departments. Distinctions had to be drawn between working meetings with and meetings with Detroit officials on policy issues and meetings with City department personnel on technical issues. Issues such as this can also be resolved within the ICC. A committee such as the ICC can be used as a forum for resolving issues between participating agencies before they become more serious problems that could potentially cripple the ability to work cooperatively on the project.

After approximately 24 months The ICC has reached agreement, at least in principle, on the general alternative for the new I-94. This plan features a five-lane freeway cross-section with retaining walls over most of the length of the project. Areas where grass slopes might be feasible and desirable are to be explored. The plan also includes three-lane, one-way continuous service drives on each side of the freeway. This plan features a cross-section with all ten freeway lanes at the same elevation. Previously, the only way a fifth lane in each direction would be possible was to elevate these lanes for approximately two and one-half miles. This is the only way to make these lanes continuous through the M-10 (Lodge) and I-75 Interchanges as they are presently configured. These interchanges were designed and built in the late 1950's and feature a tight design with many left-hand entrance and exit ramps. Initially it was assumed that redesign and reconstruction of the interchanges was not to be included in this study. Over time, however, it became the consensus of the ICC that an alternative that included all future lanes at the same elevation as the existing lanes, and the redesign of the interchanges to accommodate these lanes, was greatly preferable to all other alternatives. This would require the redesign of the interchanges which would provide the opportunity to develop a modern design with all right-hand entrance and exit ramps.

There were negative implications of such an alternative that had to be addressed. The redesign of the interchanges would require significantly more right-of-way and displacements than would have been the case with the elevated alternative. This impact had to be addressed with the City of Detroit which is understandably sensitive to the displacement of residences and businesses in the city, and Wayne State University which is a public institution and the largest real estate holder that would be impacted by the redesign of the M-10 Interchange. There were also major negative impacts of such an alternative to the ultimate project construction cost and to the cost and schedule of the Phase 1 Study. These impacts had to be addressed with MDOT management.

The City of Detroit and Wayne State University have both agreed in principle that the advantages of the new alternative would outweigh the negative impacts, and should therefore become the preferred course of action. This agreement is contingent upon efforts to minimize the negative impacts and to mitigate those that remain. Mitigation will take the general form of doing whatever is possible to relocate displaced families and businesses within the City of Detroit. The decision faced by MDOT management was not an easy one because of the scarcity of transportation funds in general, coupled with the enormity of costs for this project, and this alternative in particular. At a time when funds are very tight for maintenance and preservation of the existing system, it is very difficult to find additional funding for future major improvements. In spite of these concerns, MDOT management has committed to the development of the new preferred alternative, which includes redesign of the two freeway interchanges. The ICC prevailed, therefore, in their recommendations to pursue this new alternative.

Funding for implementation of this project, will doubtlessly require construction in a number of stages. Construction of the ultimate stage may require special funding, such as funds for development of international trade routes, or other special needs. The MDOT, as well as the City of Detroit, and SEMCOG have requested such funding.

As mentioned earlier, one of the disadvantages of pursuing this alternative, which includes the redesign of the M-10 and I-75 interchanges, is the impact on the cost and schedule of the project. These are two of the greatest challenges of Project Management and the Project Manager and MDOT management initially had some degree of reluctance to embrace the pursuit of this new alternative. This alternative will require the addition of new items to the contracted scope of services and will require the extension of the existing scope of services to cover an expanded study area. The area of study needed to be significantly expanded, both north and south, along the M-10 and I-75 Freeways. This additional work will definitely require an extension of the duration of the study project. Work could not proceed on these items until a contract amendment was successfully negotiated and approved.

The public involvement/ public information process has been quite successful in reaching large numbers of citizens with project information and, in obtaining citizen interest and input. This effort has included the support and active participation of the City of Detroit. Public informational meetings are very well attended. There continuous to be a large demand for neighborhood and outreach meetings. There has been no opposition expressed to date to this improvement project. The need for the project has been generally accepted by all involved agencies and jurisdictions, citizens in the corridor, and I-94 users. The main issues to be resolved for final acceptance include impacts on existing residential and business communities and on planned land uses. Impacts include not only the extent of additional right-of-way requirements, but vehicle and pedestrian access as well. MDOT and the consultant team are making efforts, in cooperation with the City of Detroit, to gain an enhanced awareness of planned future land developments in the corridor, especially as they relate to the Detroit economic empowerment zones. Resolution of these issues will be incorporated in the processes of the expanded public involvement schedule and the engineering and geometric of the new alternative.

One major reason for success in convincing the public of the need for the rehabilitation of I-94 has been the very well publicized support provided by Detroit Mayor Dennis Archer and MDOT Directors Patrick Nowak and Robert Welke. These public leaders have provided their full support for this project through media statements and appearances, public information videos, and project newsletter articles. The importance of support at this level for a public works project of this magnitude can not be overstated.

One of the major areas of concern throughout this study has been the viability of providing special use lanes. This concern is driven by two factors. The first is that since this is an MIS Project, a thorough analysis of alternatives to additional general use lanes is required. In this regard it should be noted that the air quality status of Southeast Michigan has been a concern. At the initiation of the study in late 1994 Southeast Michigan was classified as a non-attainment area for air quality. This alone was a driving force in including Transportation Demand Management (TDM) options in the study of alternatives. More recently, southeast Michigan has been reclassified as an air quality attainment area. This reclassification has reduced the urgency of considering TDM options but it by no means totally eliminates the wisdom of including them in whatever is selected as the final alternative.

The second factor driving the consideration of special use lanes is the very real potential for inclusion of this section of I-94 in an International Trade Route. I-94 connects to the Detroit, Michigan/Windsor, Ontario border crossing facility, the Ambassador Bridge, via its interchange with I-75. I-94 also connects to the Port Huron Michigan/Sarnia Ontario border crossing facility, the Blue Water Bridge. Border crossing traffic volumes continue to increase. Over 9 million vehicles crossed the U.S./Canada border in 1994 at the Ambassador Bridge alone. This Detroit/Windsor border crossing facility is the most heavily used single border crossing facility for U.S./Canada Trade. International trade crossing at this site accounts for nearly one-half of all trade crossing the U.S./Canada border and rivals that of the U.S. and Mexico in Texas and California combined. The importance of I-94 to International trade in North America cannot be overstated. Michigan leads the U.S. in trade with Canada and is one of the leading states in trade with Mexico.

In light of the importance of I-94 to International Trade and the prudence of considering TDM options, consideration needs to be given to not only providing special use lanes, but perhaps multiple use of special use lanes. Consideration will be given to the possibility of using these lanes as HOV during peak hours and truck lanes during off peak hours. Intelligent Transportation Systems (ITS) and Automated Highway Systems (AHS) will also be explored to aid in managing congestion and in pursuing state of the art technology for providing a "seamless border" for international trade traffic. Studies are also underway to provide multi-modal rail connection points for I-94 in the Detroit area.

Evaluation Of The Impact Of MIS Requirements

Inclusion Of Impacted Jurisdictions and the MPO in the Decision Making Process

The MIS requirements in ISTEA have, on balance, had a positive impact on this project to date. First, it helped to make the ICC a reality and a success. To be certain, such a committee would have most likely been formed for this project with or without ISTEA. However, its makeup, role, and acceptance as a consensus building body by officials of its member agencies and governmental units, would be questionable. The MIS requirement of ISTEA helps to define the role and the importance of this committee. The author is convinced that these requirements have been invaluable in bringing together a committee of such high ranking representatives thus ensuring its success. One of the great successes of the ICC is that it has allowed MDOT, the City of Detroit, Wayne County, and SEMCOG to pursue the issues and common goals of this project while minimizing "spillover" effects or distractions by other, sometimes divisive political issues. While the ICC has not been a perfect insulation from outside political issues, it has been enough so that this study can continue to progress. The author is also convinced that, without the success of the ICC, there would be no chance for the success of the study in reaching an acceptable conclusion. An acceptable conclusion could be defined as one that would provide for a modern urban freeway, an international trade route, and a facility that would contribute to the development of the economic empowerment zones surrounding I-94.

Public Involvement/Information

It is a fact that, with or without the MIS requirements of ISTEA, the I-94 rehabilitation study would have had an extensive public involvement/public information effort. This effort would have been impressive by MDOT past practices, and MDOT has always had a very comprehensive public information program. It is also true, however, that the MIS requirements articulate the need for an extensive public involvement/information effort. The amount of the contract initially devoted to public involvement/information was soon found to be inadequate. The contract was amended soon after its initiation in order to provide for an increase in this effort. The current amendment has increased the cost of all phases of the study so the cost allocated for the public involvement/information effort has again increased. The MIS requirements have helped to legitimize such unprecedented public involvement/information costs in a period of uncertainty for transportation funding.

As mentioned earlier, this effort has included many forums including the formation of a Citizens Advisory Group that includes neighborhood and citizen interest group leaders, making informational presentations at neighborhood, church, and special interest groups meetings as part of a neighborhood outreach program, well publicized and well attended public informational meetings, newsletters, a citizen opinion poll, and eventually, a formal public hearing. The demand for speakers to go out to citizen and business group meetings has been tremendous and this has been an excellent vehicle for reaching large numbers of citizens.

One factor that has contributed greatly to the success of the public involvement/information program has been the active cooperation and participation of the City of Detroit at major public meetings and some neighborhood meetings as well. This participation was arranged during contacts set up through the context of the ICC, and by special efforts of the sub consultant responsible for the Public Involvement effort. To the extent that this cooperation and participation was made possible through the working of the ICC, the success of the public involvement/information effort can largely be attributed to the MIS requirements.

Multimodal Considerations

To be sure, modal and technology alternatives to providing more capacity in the form of general use lanes would be a part of the I-94 rehabilitation study with or without the requirements of MIS. It is also fair to say, however, that when Southeast Michigan was reclassified as an air quality attainment area, there may not have been the urgency to pursue such options. The provision of special use lanes for exclusive HOV use, heavy commercial vehicle use, and the provision for advanced technology for Intelligent Transportation Systems, are all very much a part of the I-94 study. This remains true even though traffic studies thus far indicate that success for an HOV lane on this seven mile section alone are questionable. Rather than accepting these findings as a fatal flaw, MDOT has commissioned a study of HOV viability for the freeway network in Southeast Michigan. One would have to assume that MIS requirements, along with International Trade Route considerations, play an important part in driving this effort. In context, it must be remembered that Michigan has never implemented a HOV lane to date. Implementation here would be precedent-setting in a state that rightfully takes pride in its leadership role in manufacturing of automobiles and commercial vehicles.

Additionally, studies are underway to implement a modal transfer facility that would provide access between I-94 and I-75 and the Junction Yard rail center. This would facilitate modal transfers in Detroit for national as well as international trade.

Observations Relating To MIS Requirements Based On The I-94 Study

Reaching consensus for a major public works project within a group such as the ICC takes time. An extensive public involvement/information program also takes time. All conflicting goals and objectives must be articulated so that truly acceptable solutions can be reached. Reaching agreement in stages, from goals and objectives, general alternatives, to specific details is imperative. Time allotted for the study must take into account a reasonable time for a committee like the ICC to work through its purpose and reach consensus. In retrospect, 30 months was not sufficient to accomplish success. For many projects, such as this one for urban freeway renewal, time is the most important factor because of the critical state of deterioration of the existing facility. If at all possible, however, it is important to allow time for the difficult effort of consensus. This may even require that some major maintenance work proceed even if some of this work might have to be removed before its lifetime is completed. To be certain, these are difficult decisions to make since they involve the expenditure of scarce resources.

It is imperative that a thorough understanding of MIS requirements be established initially for all study participants. This includes consultants when applicable. When consultants are employed, MIS requirements must be articulated in the Scope of Services for the consultant contract. For the I-94 Project, it was very helpful that the prime consultant firm was very cognizant of MIS requirements.

It is imperative that the action plan for public involvement/information be established at the outset of the study, and that the plan is universally accepted. This project required a multifaceted approach which includes media appearances and informational spots, project newsletters, public meetings, and outreach efforts such as seeking out and attending neighborhood and interest group meetings. For the I-94 Project, It was extremely helpful that the consultant team that was selected, included a public information firm, Jay Gregory and Associates, that was familiar with city government and neighborhood and business groups, and had much prior experience with public involvement in Detroit. The enormity of the public involvement/information required of a project such as this one must not be underestimated. That the was the case on this project initially and corrections had to be made. These requirements must be continually reassessed. State DOTS with urban MIS projects may be experiencing, as MDOT is, a higher percentage of project costs devoted to public involvement/information than was the case on previous projects.

Major project decisions are made in the context of the ICC that sometimes have major cost and project scope implications. These are decisions that MDOT has a part in, but not total control over. It is imperative that these decisions are periodically reviewed and approved by MDOT management. This is doubtlessly true for other ICC represented agencies as well. The management and/or political leadership of participating jurisdictions or agencies should never be surprised by ICC recommendations.

Conclusion

The MIS requirements certainly helped to articulate many of the elements that are required for the success of this study. Yes, there would have been a large public involvement/information effort with or without MIS requirements, there would have been some effort towards intermodal connections, special use lanes, and ITS technology, and there would probably have been an ICC. On the other hand, the public involvement/information effort may not have been so great as it has been, and continues to be, and there may have been greater reluctance to devote the percentage of total phase I cost and time to this effort. There may not have been the well publicized support for this project by city and state leaders and the MPO, and selling the need for the project to impacted citizens and businesses may therefore have been much more difficult.

Without the MIS requirements, the interest in developing special use lanes to play a role in increasing mobility may have waned after the change in air quality status for Southeast Michigan. Additionally, while the ICC would probably have existed, it was the MIS that really defined its role and the role of its members.

There were some misgivings at state DOT level at the outset, since the MIS section of ISTEA articulates requirements that MDOT, and doubtlessly most state DOTS would follow on major urban projects anyway. These misgivings were dispelled early in the study when it became apparent that these requirements were more of a help than a hindrance. If MIS does nothing else positive, it plays a major role in legitimizing project procedures and expenses and provides a standard for performance of the required elements of the study.

Modeling Procedures for Conducting Multimodal Major Investment Studies

Richard S. Marshment, University of Oklahoma

Abstract

Proposed solutions to transportation problems in heavily congested urban corridors frequently involve different modes and result in transfer payments among the modes. Traditional procedures for evaluating transportation alternative are designed for specific modes, ignoring impacts on other modes and/or impeding comparisons of multimodal options. Even with evaluation processes capable of crossmodal comparisons, such as benefit-cost analysis, travel forecasting procedures too often bias results or produce counterintuitive outcomes. These problems arose in a major investment study (MIS) of alternatives in two congested corridors in the Oklahoma City region. The alternatives includes light rail transit and high occupancy vehicle lanes. The MIS explicitly addressed impacts on private passenger cars, trucks, commercial traffic, and external travelers, imposing unusual demands on the travel modeling process. Among the modeling issues which had to be addressed were trip purpose definitions, vehicle classifications, accounting for modal shifts, aggregating travel time savings for benefit calculations, and specifying impedance functions for trip distribution and modal split estimation.

The presentation will describe the modeling procedures developed to conduct a comprehensive benefit-cost analysis of the Oklahoma City alternatives which considers all modal impacts. The specific topics which will be discussed include:

The procedure used to convert traditional trip purposes classified by type of vehicle used.

1 The method of accounting for modal shifts given a fixed trip table, i.e. the total trips for all alternatives are the same.

2 The generalized cost functions used to estimate mode splits and trip distribution.

3 The model summaries required to estimate the benefits of the alternatives, specifically accounting for the generalized cost functions used in mode split and trip distribution.

4 The system used to develop numerically and logically consistent trip tables and networks for passenger car, transit, and high occupancy vehicle trips.

5 The model developed to estimate total highway and transit user benefits.

Modelling Carpool and Transit Park-and-Ride Lots

William G. Allen, Jr.

Park-and-Ride (PnR) lots are an increasingly common element of many areas' plans for air quality conformity. By making it easier to carpool or use transit, PnR lots should theoretically reduce the number of persons driving alone, especially to work. However, accessing a PnR lot still requires a vehicle trip (usually a "cold start" trip) and the vehicle-miles travelled (VMT), congestion impact, and emissions of the PnR access trip should be accounted for in order to produce a proper accounting of the potential air quality benefits of PnR lots.

Few, if any, travel models estimate the impacts of carpool PnR lots. If carpool lots are to be reasonably considered as part of a region's air quality conformity strategy, their impacts must be analyzed. Some *ad hoc* manual methods or geographic information system (GIS)-based have been developed, but the author is unaware of any network-based models which are sensitive to such lots. Careful, detailed analysis of carpool lots is important, because such lots are generally not considered to have a major impact on carpool formation (and properly so). Further, given the time and distance necessary to access the lot, it is entirely possible that some carpool PnR lots could actually *increase* VMT. The author contends that in order to accurately assess this trade-off, a more rigorous network-based methodology is needed.

Many travel models in the larger urban areas accommodate transit PnR lots. The analyst must usually manually connect each lot to the appropriate transit stop nodes, although some models have automated all or part of this process. In such cases, lot choice is unaffected by the lot's characteristics or highway conditions. Also, few models account for the vehicle trips and VMT resulting from drive-access transit trips. Although usually small on a regional scale, this VMT can be more significant when comparing air quality scenarios. As with carpool PnR lots, it is not clear that adding transit PnR lots always improves air quality.

The procedure described here addresses these concerns. It permits the rigorous analysis of the impacts of both carpool and transit PnR lots within a network-based model structure. This procedure has been implemented in the travel model recently developed for the Reading, Pennsylvania area (Berks County). Although not a large metropolitan area (urban area population about 330,000), Reading is in moderate non-attainment of air quality standards and is required to develop plans to achieve attainment. The new travel model was developed with the specific goal of being reasonably sensitive to the variety of transportation control measures (TCMs) that are being considered in large and small areas across the country. The methodology described here should be generally applicable to other areas as well.

As noted above, estimating the impacts of transit PnR lots with a regional travel model is not new. However, it is only recently that automated procedures have been developed to account for peak period highway network conditions in modelling PnR lot access, such as in the new model being developed for the Washington, D.C. area. The Seattle area's model reportedly takes advantage of new capabilities in the EMME/2 software package to examine the home-lot and lot-work connections. However, the author believes that the Reading model is the first regional travel model to handle both carpool and transit PnR lots in a consistent manner.

Methodology

The Reading methodology handles PnR lots through changes in three major model components: transit network coding, highway network coding, and the mode choice application program. These are described below.

Transit Network Coding

This procedure, along with certain simplifying assumptions, permits easier transit network coding. The analyst is not required to use judgment in identifying the zones that are in each PnR lot's service area and is not required to code specific zone-lot connector links. In the transit path building and skimming process, no drive-access paths are built and no PnR lots are specified; only walk access is coded.

In transit network coding, the analyst need only ensure that transit routes which serve a PnR lot have walk access connections from the zone in which the lot is located. That is, if there is a transit PnR lot in zone 324, then zone 324 must have a proper walk connection to the nearest transit stop node. In some cases, this may require coding transit routes somewhat differently than they actually operate.

One of the trade-offs of using this procedure is that the exact location of transit PnR lots cannot be specified; only the zone in which the lot is located is specified (this can be viewed as both an advantage and a disadvantage). Thus, this procedure effectively requires zones that are fairly small in area and basically assumes that the PnR lot is in the vicinity of the zone's center. It also assumes that there is never more than one PnR lot in a zone, or that if there are more than one, they effectively function as one lot.

The assumption of small zones also helps the analyst avoid one other tedious task: the calculation of the percent of each zone within walking distance of a transit line. Most models which handle walk and drive access require each zone to be subdivided by market area and this has proven to be a time-consuming and error-prone process (some newer models attempt to automate this via a GIS-like process, but the accuracy of such procedures is questionable). By using small zones, all zones can effectively be classified as either all-walk (100% of the zone's houses and jobs are within walking distance of transit) or all-drive (none of the zone is within walking distance). All-walk zones are defined as those which have a walk-access connection between the zone centroid and a transit stop node. Obviously this is an over- simplification of reality, but it is likely to be sufficiently accurate for all but the largest urban areas.

Highway Network Coding

The Reading highway network follows the increasingly common convention of using an "HOV flag" network variable to identify those links which are restricted to high-occupancy vehicle (HOV) use during certain times of the day. Although no such links currently exist in the Reading area, it is anticipated that they might be planned or built in the future. Thus, the model is set up to handle them. The highway skim process is set up to build and skim single-occupant vehicle (SOV) and HOV paths separately.

Separate SOV and HOV travel times are not essential to this PnR lot procedure, but if they are available, the procedure uses them. All travel times and distances from carpool PnR lots to work zones use the HOV paths.

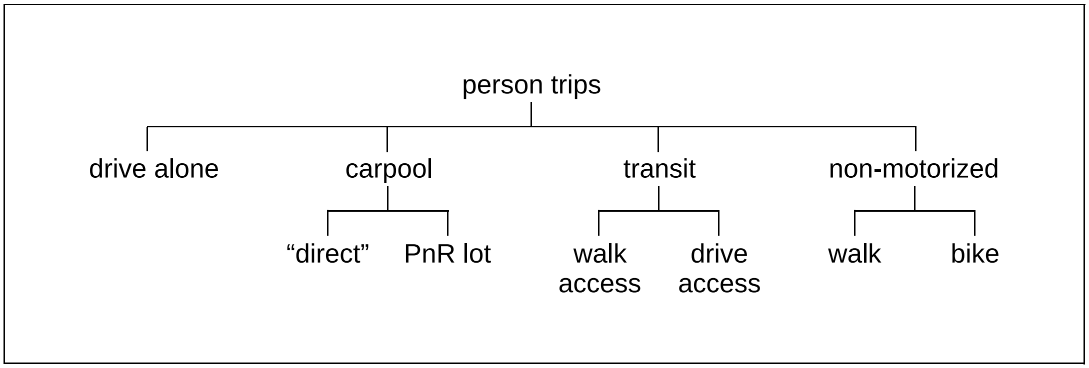

Figure 1: HBW mode choice model structure

Mode Choice Application Program

The Reading model uses a custom-written stand-alone FORTRAN program to apply a nested logit mode choice model. Figure 1 illustrates the structure of the home-based work (HBW) model. In the Reading model, HBW is the only trip purpose for which the PnR lot procedure is applicable, but that assumption could be easily modified.

Carpools (assumed to be HOV2+) are further split into those who travel directly from home to work and those who use a carpool PnR lot. That is, they leave home in low-occupancy vehicles and arrive at a lot, where they form high-occupancy vehicles for the subsequent trip to work. The transit nest is a fairly standard one for models which handle walk- and drive-access. The Reading model also assumes that all drive access to transit is via formal PnR lots. This is likely to be reasonable for all but the largest urban areas. “Informal” drive access is more difficult to handle and cannot be accommodated by the procedure described here.

The locations (zones) of all transit and carpool PnR lots are specified as inputs to the mode choice application program. The Reading model’s program permits up to 50 lots of each type to be specified. Inside that program, Step 1 is to derive the time and cost for the two types of carpool paths: PnR and direct. The direct path is described as follows for the production zone to the attraction zone:

- time = time on the HOV path plus about 1.8 min to account for the assumed additional time to pick up a passenger
- cost = distance on the HOV path, multiplied by the auto operating cost/mile, divided by the observed (surveyed) average HBW carpool occupancy of 2.674 to get a cost per person trip

The PnR path is described as follows:

- time = SOV path time for the production zone to each PnR lot zone plus HOV path time from each PnR lot zone to the attraction zone
- cost = SOV path distance for the production zone to each PnR lot zone, multiplied by the auto operating cost/mile, divided by an assumed average occupancy of 1.05, plus the HOV path distance from each PnR lot zone to the attraction zone, multiplied by the auto operating cost/mile, divided by 2.674

- the number of spaces in the PnR lot and the lot quality also influence this calculation (see below)

All possible production zone-PnR lot-attraction zone paths are evaluated and the one with the lowest total impedance (i.e., weighted combination of time, cost, and lot characteristics) is chosen. In future applications, this calculation could probably be modified to estimate the probability that each of several different lots might be chosen.

Step 2 is to do essentially the same calculation for the transit path. All zones potentially have a PnR path, constructed as follows:

- auto access time = SOV path time for the production zone to each PnR lot
- run time = walk-access transit path time from the PnR lot to the attraction zone
- out-of-vehicle time = wait time at the PnR lot, plus access walk time from the PnR lot's centroid to the nearest stop node (this serves as a surrogate for the time to walk from one's car to the transit stop), plus egress walk time at the attraction zone, plus any transfer wait time from the PnR lot to the attraction zone
- cost = SOV path distance for the production zone to each PnR lot, multiplied by the auto operating cost/mile, divided by an assumed 1.05 auto occupancy, plus half the daily cost of using the PnR lot divided by 1.05, plus the one-way transit fare from the PnR lot to the attraction zone
- transfers = the number of transfers required to travel from the PnR lot to the attraction zone

As with the carpool lot, all possible production zone-PnR lot-attraction zone paths are evaluated and the one with the lowest total impedance (i.e., weighted combination of time and cost) is chosen.

Step 3 is to perform the carpool split. A binary logit model is used to calculate the total carpool split between direct and PnR paths. The utilities of these choices is calculated as follows:

$$U(direct) = -0.0160 * (HOV\ time[P\text{-}A] + 1.1 * (2.674-1)) - 0.0015 * HOV\ distance[P\text{-}A] * op\ cost/mi / 2.674 \quad (1)$$

$$U(PnR) = -0.0160 * (SOV\ time[P\text{-}L] + HOV\ time[L\text{-}A] + 1.1 * (2.674-1)) - 0.0015 * (SOV\ distance[P\text{-}L] * op\ cost/mi / 1.05 + HOV\ distance[L\text{-}A] * op\ cost/mi / 2.674) + 0.0320 * lot\ type + 0.00032 * spaces - 2.8 \quad (2)$$

where:

P = production zone
L = PnR lot zone
A = attraction zone
- all times are in minutes (AM peak period), distances are in miles, and costs are in cents (1994 $)
- the auto operating cost is 8.7 ¢/mi

The type of lot is defined using an index of 1 to 5, approximately indicated as follows:

1 = unpaved lot, with “trailblazer” signs
2 = signs + gravel paving
3 = signs + asphalt paving
4 = signs + asphalt paving + lighting
5 = signs + asphalt paving + lighting + fencing (or other similar amenities)

It must be emphasized that no formal carpool PnR lots currently exist in the Reading area and no observed data was available to calibrate the coefficients on lot type or number of spaces. The lot type coefficient was synthesized by assuming that each “step” improvement in lot quality would be perceived as equivalent to 2 minutes of time savings. It seems logical to assume that improvements to the parking surface and the security of the lot should make the lot more attractive, thereby slightly increasing its usage.

Similarly, the coefficient on number of spaces was synthesized by assuming that every 50 additional spaces would be perceived as equivalent to 1 minute of time savings. As noted below, tests of these coefficients produced reasonable results. It was judged very important for the model to be responsive to changes in carpool PnR lot quality and size, because the plans of several Pennsylvania jurisdictions for air quality conformity include such improvements.

Equations (1) and (2) are not only used to determine the split between direct and PnR lot carpooling, but are subsequently combined in a log sum calculation to derive the total carpool utility for the prime mode choice calculation, as shown below:

$$U(\text{carpool}) = \ln(e^{U(\text{direct})} + e^{U(\text{PnR})}) \qquad (3)$$

According to equation (3), the mere presence of a viable carpool PnR lot will always increase the carpool mode share for a given O-D pair. This model will estimate that adding a carpool PnR lot will reduce the direct carpool sub-mode’s share of the total carpool market, but will also increase the total carpool share. Both effects are related to the location, quality, and size of the lot, compared to a direct carpool trip from production to attraction zone.

Step 4 is to perform the walk- vs. drive-access split for transit in an analogous manner. The utilities are as follows:

$$U(\text{walk acc.}) = -0.0250 * OVT[P\text{-}A] - 0.0250 * IVT[P\text{-}A] - 0.0031 * FARE[P\text{-}A] - 1.0 * XFER[P\text{-}A] \qquad (4)$$

$$U(\text{drive acc.}) = -0.0250 * OVT[L\text{-}A] - 0.0250 * IVT[L\text{-}A] - 0.0031 * (FARE[L\text{-}A] + 0.5 * LotCst + SOV\ distance[P\text{-}L] * op\ cost/mi / 1.05) - 1.0 * XFER[L\text{-}A] - 0.0250 * (DACC[P\text{-}L] + 1.1 * (1.05-1)) + bias(inc) \qquad (5)$$

where:

OVT = out-of-vehicle time (= access walk + egress walk + initial wait + transfer wait), min.
IVT = bus running (in-vehicle) time, min.
XFER = no. of transfers
FARE = one-way transit fare, cents
DACC = drive access time, min. (from AM peak SOV highway paths)
LotCst = daily cost of parking at the PnR lot, cents

bias(inc) = bias coefficients by household income quartile:

Income	Coefficient
low	-5.6132
low-mid	-1.2457
high-mid	-0.7789
high	-0.7450

If walk-access transit service is unavailable for a given O-D pair, U(walk acc.) = 0. Also, if DACC exceeds 30 minutes, U(drive acc.) = 0. Finally, if the total unweighted transit travel time (OVT + IVT + drive acc. time) exceeds 120 minutes for either access mode, the U for that access mode is 0. According to equations (4) and (5), the walk vs. drive-access split is sensitive to the relative level of transit service via either access mode, the cost of parking in the PnR lot, the time and cost involved in driving to the lot, and income level. Higher income travellers are much more likely to drive to transit than lower income travellers. Unlike the carpool model, some observed data on transit PnR usage was available for the Reading area, and the transit PnR coefficients are based on that data.

As with the carpool mode, equations (4) and (5) are not only used to determine the split between walk- and drive-access transit, but are subsequently combined in a log sum calculation to derive the total transit utility for the prime mode choice calculation, as shown below:

$$U(\text{transit}) = \ln(e^{U(\text{walk acc.})} + e^{U(\text{drive acc.})}) \qquad (6)$$

Results

The Reading model's mode choice application program produces a report such as the one shown in Figure 2. On the transit side, the report shows the number of persons boarding transit in each zone's PnR lot and the number of cars entering the lot. On the carpool side, "vehicles in" is the number of SOVs entering the lot, "vehicles out" is the number of HOVs exiting the lot, and "vehicles parked" is the number of vehicles remaining in the lot during the day.

Table 1 shows the results of varying the quality of a carpool parking lot. The base case represents a situation with no carpool lots at all. The remaining rows show the results from adding one hypo-

```
      Report 7: Park-and-Ride Lot Activity

            Transit                         Carpool

      Persons   Vehicles    Persons   Vehicles   Vehicles   Vehicles
Zone  In/Out    In          In/Out    In         Out        Parked
---------------------------------------------------------------------
63        87          83          0          0          0          0
432        0           0        105        100         39         61
466       63          60          0          0          0          0
```

Figure 2: PnR lot report

Table 1: Carpool PnR sensitivity

Scenario	Regional Daily HBW Carpool Person Trips			Vehicles Parked
	Direct	PnR	Total	
Base	38,761	0	38,761	0
Type 1, 100 Spaces	38,714	105	38,819	61
Type 2, 100 Spaces	38,712	110	38,822	64
Type 3, 100 Spaces	38,710	116	38,826	67
Type 4, 100 Spaces	38,707	121	38,828	70
Type 5, 100 Spaces	38,704	127	38,831	74
Type 5, 25 Spaces	38,706	123	38,829	71
Type 5, 50 Spaces	38,706	124	38,830	72
Type 5, 200 Spaces	38,701	134	38,835	77
Type 5, 500 Spaces	38,692	155	38,847	90

thetical carpool PnR lot in zone 432, which is located about 10 minutes from downtown Reading, about 1.5 mi from a moderately heavy arterial leading into town.

The results of this analysis suggest that there is a "natural" market for about 100-120 carpool PnR lot users and that this estimate is not very sensitive to the quality of the lot - improving the lot from "worst" to "best" produces a 21% increase in lot usage. The estimate is also rather insensitive to the size of the lot and indicates an additional feature of this procedure: lot usage is influenced by lot size, but is not constrained to the lot's capacity.

Table 1 also indicates that as the PnR lot is improved or expanded in size, the PnR share of total carpool trips increases but the total carpool usage also increases. This hypothetical PnR lot draws about half its users from direct carpooling and the rest from the other travel modes. In this example, it would appear that a carpool PnR lot in zone 432 could be sized at around 100 spaces to accommodate current demand and allow for modest future growth.

Table 2 presents a similar analysis for the existing lot in zone 63. This lot is located at a local sports stadium about 10 min. north of the Reading CBD and is served by two local bus lines with headways of 22 and 15 min.

According to these results, PnR usage at this location is extremely insensitive to a fee that might be charged for PnR use. Charging a $2/day fee reduces the lot's usage by only 21%, which seems rather low. Either the coefficient on PnR lot cost should be revisited, or perhaps there is a natural market of transit users for this PnR lot also, which might be relatively unaffected by fee increases. Changing the frequency of transit service from this lot also has a fairly minor effect on ridership and lot usage. These results similarly indicate that the likely near-term demand for parking at this location is about 100 spaces.

Table 2: Transit PnR sensitivity

Scenario	Regional Daily HBW Transit Person Trips			Vehicles Parked
	Walk Access	Drive Access[a]	Total	
Base	5,890	150	6,040	83
50 ¢/day fee	5,893	141	6,034	74
$1.00/day fee	5,896	133	6,029	66
$2.00/day fee	5,900	119	6,019	52
no fee, double headways	5,840	137	5,977	70
no fee, halve headways	5,924	162	6,086	95

a. Total for all existing transit PnR lots.

The model's results are shown in Tables 1 and 2 to the nearest trip. This should not be interpreted as a

```
          Report 8: Grand Integer Trip Totals

Table   Mode                                               Trips
-------------------------------------------------------------
1       Drive Alone Person/Vehicle                        270762
2       Carpool Person (direct)                           389761
3       Carpool Vehicle (direct)                           14496
4       Carpool PNR Orig.-Dest. Person (HBW)*                  0
5       Carpool Origin-to-PNR Lot Vehicle (HBW)*               0
6       Carpool PNR Lot-to-Dest. Vehicle (HBW)*                0
7       Walk-Acc. Transit Person                            5890
8       Drive-Acc. Transit Orig.-Dest. Person (HBW)*         150
9       Drive-Acc. Transit Orig.-PNR Vehicle (HBW)*          143
10      School Bus Person (SCH)                                0
11      Walk/Bike Person                                   15969

      (* Defined as zero for non-HBW purposes.)
```

Figure 3: Modal trip table total report

claim that this (or any) model is accurate to the nearest trip. In fact, the “error band” of this model undoubtedly exceeds the small differences among the scenarios shown here. However, it is believed that these results provide a reasonable indication as to the model’s relative sensitivity to the different scenarios.

The mode choice application program outputs 11 modal trip tables for each trip purpose. Figure 3 provides a sample of a report listing the total trips on each table. Output tables 2 and 3 are those carpoolers who travel directly to their workplace. Output table 4 includes linked carpool person trips who use a PnR lot, but the trips are stored in this table in the production-attraction zone cell, to facilitate subsequent evaluation. Output tables 5 and 6 represent the unlinked home-lot and lot-work segments of carpool PnR lot users. Similarly, output table 8 includes the linked drive-access transit users, stored in the production-attraction zone cell. Output table 9 represents the home-lot vehicle trip that constitutes the drive-access portion of the trip. This is necessary to account for the VMT that transit PnR lots create.

Conclusions

This paper documents a new implementation of a procedure that handles both carpool and transit PnR lots in a consistent manner. The presence of these lots is modelled in terms of the trade-offs among travel time, cost, and lot characteristics. Due to a lack of observed data, some of the relationships and sensitivities have been synthesized. These coefficients should be updated in the future when observed data on PnR usage becomes available.

This procedure provides a reasonable accounting of the effects of PnR lots. These lots can be expected to increase carpool and transit usage slightly, but not by much. This process also accounts for the fact that an increase in PnR carpooling will “steal” trips from direct carpooling and transit, as well as from drive alone. Increases in PnR transit use will steal trips from walk-access transit use and carpooling also. In addition, the VMT arising from home-lot access is explicitly estimated.

Sensitivity testing has indicated that the model’s estimates of potential carpool and transit PnR lot use are conservative, but probably within the bounds of experience in other areas. The model’s output is consistent with the needs of air quality conformity analyses. Although a complex, custom-written computer program was required to implement this procedure, this is merely an extension of efforts currently being done in other areas.

Acknowledgments

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Short-Term Model Improvement: Switching to Life Style Models of Trip Generation

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Abstract

The Florida Department of Transportation (FDOT) uses a cross-classification trip production model within the Florida Standard Urban Transportation Modeling Structure (FSUTMS). Recent research has indicated that several changes in the model are needed to do a better job of estimating trip generation. This study developed and implemented a life-style trip generation model. The revised model expands the existing trip purposes to include home-based school and truck trips. Recent travel surveys and census data were used in all statistical analyses. The revised models use estimation from multiple classification analysis, ANOVA and multiple regression. The results of these statistical models show a better trip production model. The revised models also implement polynomial regression based stratification models and a “frataring” technique to make optimal use of census data in estimates of the future zonal characteristics needed by the “life-style” model.

Tour-Based Travel Demand Modeling in the U.S.

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Abstract

With few exceptions, urban area and statewide travel model systems in the U.S. use the traditional four-step modeling process. This process relies on the individual trip, from origin to destination, as the unit of analysis. While the four-step process has served planners well for decades, recognition of its inability to adequately perform certain analyses, and recent research and advances in computing capacity, have prompted a reexamination of this paradigm.

Tour-based modeling, where the unit of travel is defined as the tour from home to one or more destinations and then back home, is a reasonable near-term alternative to the four-step process, where the individual trip is the unit. While this alternative cannot solve all of the problems of the four-step process, it does solve one of the most critical problems: the treatment of individual trips as independent decisions where the effects of other activity decisions are not considered. Tour-based modeling may be viewed as a step towards activity-based modeling, which treats travel as a derived demand from the desire for activities.

Although tour-based model systems are relatively new to the U.S., models have been around in some European countries, such as Sweden and the Netherlands, for several years. Tour-based models do not require data beyond what is needed to develop a four-step travel model system. This paper describes the two currently operational U.S. tour-based travel model systems, in Boise, Idaho, and New Hampshire.

The Boise model system was completed in 1994. This model system includes the following logit model components: auto ownership, tour generation (number and purposes), primary destination choice of tour, tour type (number and stops), and secondary destination choice. The models were estimated using data from a traditional household travel survey. The outputs of these models are converted to traditional origin-destination trip tables and assigned to a highway network using traditional equilibrium assignment methods.

The New Hampshire statewide travel model system is a logical next step from the Boise model system. This system was completed in 1996 and consists of the same components as the Boise system, plus mode choice and time of day models. These logit models were estimated using data from a household activity-travel survey, a household stated preference survey, and transit on-board surveys. Since the stated preference and transit surveys were trip-based, a two-state mode choice model is used. Tours are classified as “auto,” in which the traveler brings an auto from the home, or “non-auto.” A trip-based model is used for links in each type of tour.

The implementation of the model systems demonstrates that tour-based models are an effective and available process for travel modeling.

Adding Car Occupancy to the Calgary Travel Demand Model Using Combined RP/SP Data

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Abstract

The existing EMME/2 four-step travel demand model of Calgary has been extended to include explicit representation of car occupancy.

The previous version of the model included ‘car’, ‘transit’ and ‘walk’ as the model alternative in a nested logit mode choice model for home based work trips, and it performed the conversion from auto person trips to auto vehicle trips using an exogenously-specified car occupancy factor.

In response to a desire to make this car occupancy factor endogenous to the model, a survey was designed and conducted to obtain revealed preference (RP) and stated preference (SP) observations of choice of mode and choice of car occupancy in particular for home to work trips. These observations together with the observations used to develop the previous version of the model provided three data sets:

- a set of 3349 RP observations of choice among ‘car’, ‘transit’, “walk’ and ‘cycle’ from year 1991;
- a set of 659 RP observations of choice among ‘car drive alone’, ‘car with 2 people’, ‘car with 3 or more people’, ‘transit’, ‘walk’, and ‘cycle’ from year 1995; and
- a set of 33365 SP observations of choice among different auto occupancy alternatives from year 1995.

These three data sets were used together in a combined estimation process to develop a nested logit model with ‘transit’, ‘walk’ and ‘cycle’ as mode alternatives along with car split into ‘car drive alone’, ‘car with 2 people’ and ‘car with 3 or more people’ as further alternatives. This was done using ALOGIT, with separate tree structures, scaling factors and alternative specific constants among the different data sets as appropriate.

The resulting coefficient estimates seem reasonable, and indicate that the appropriate nesting structure has the ‘car with 2 people’ and ‘car with 3 or more people’ alternatives in a nest with ‘transit’, not with ‘car drive alone’. The resulting mode choice model is implemented in EMME/2, with the alternative specific constants adjusted to match aggregate mode shares observed of reach mode and car occupancy alternative. The results of the mode choice model are now used to allocate people to cars directly, thereby providing an endogenous treatment of car occupancy as desired.

This paper outlines what was done in this work and discusses the issues encountered. As such, it presents a process for developing an updated model with new features that is appealing because it draws on the strengths of both RP and SP data and it reduces the size of the new data requirements by employing previously collected data.

Considering Telecommunications for all Trip Types in a Metropolitan Region's Transportation Model

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Abstract

Voice, data, and video telecommunications usage is now growing rapidly for all kinds of service delivery, including government, education, banking and brokerage, health care, retail shopping, real estate, and tourism. Teleservices delivered via telemarketing centers, teller machines, kiosks, web sites, wired classrooms, video conferencing rooms, and telemedicine networks change the patterns of customer movement as surely as teleworking changes patterns of commuting and business meetings for workers.

Telecommunication is both a substitute for travel, and a stimulant of travel. Local government transportation planning still mostly assumes that the impact of telecommunications on travel is neutral, because planners cannot yet sort our what the impacts are and how they should be included in the typical four-step travel model.

The authors have begun to address telecommunications impacts on travel and travel modeling in an ongoing series of projects, beginning with MPOs serving metropolitan Seattle-Tacoma and Southern California. In this presentation, we provide a framework for understanding how telecommunications can change the volume, timing, length, routing, and mode of trip making. We factor telecommunications into layers and describe how to overlay various telecommunications applications onto different trip destination and purposes. Then we provide several ways of putting telecommunications into the current metropolitan travel model, and comment on how telecommunications can be merged into the results of the travel model.

Integrating ISTEA Management Systems into Oregon's Planning Process

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Abstract

Even though Congress made developing the ISTEA management systems voluntary in the National Highway System Designation Act of 1995, the Oregon Department of Transportation (ODOT) is continuing to develop the systems because managers see them as effective ways to identify problems and as effective decision-support tools.

Oregon has a well-developed transportation planning process. Its statewide, multimodal transportation plan was adopted in 1992. To refine the policies in the plan and address specific corridor and modal issues, ODOT has been developing corridor plans and bicycle/pedestrian, public transportation, rail and now highway modal plans. For corridor plans, the management systems are identifying congestion, intermodal and safety problems and the availability of public transportation. For the Highway Plan, the management systems are identifying needs, comparing needs among elements of the system, and making a significant contribution to resource allocation policies.

The State Transportation Improvement Program (STIP) currently under development relies on management system information. It emphasizes preservation of the existing infrastructure and is based on priority needs and locations identified through the pavement, bridge, public transportation and safety management systems.

Currently, management system tools include maps and written reports involving infrastructure conditions, prioritized needs, high priority accident locations, and projections of travel times. All systems are developing computer software and will be making information accessible electronically. A pilot project placing management system information on a GIS was completed in the fall of 1996.

The planning process is pushing ODOT to integrate the management systems and to make consistent assumptions across systems. The paper will further explain how the integration into ODOT's processes is being implemented.

An Integrated GIS Solution For Estimating Transportation Infrastructure Needs: A Florida Example

Gerry L. Harter, Dames & Moore, Inc.

Abstract

In 1991, one of the most important pieces of legislation in history was signed into law. The Intermodal Surface Transportation Efficiency Act (ISTEA) requires traffic monitoring and systems management monitoring of pavement, bridges, safety, congestion, public transportation facilities, and intermodal facilities. These systems call for coordinated efforts to collect, manage, analyze and store transportation related data. With these new requirements come opportunities to use existing technologies and resources to develop state of the art information storage, retrieval and management processes.

GIS-T (GIS for transportation) is one of the tools that will be used extensively in upcoming years to manage the information requirements of ISTEA. More specifically, GIS coupled with an integrated server-client based information system will become the standard, replacing many existing stand-alone, subgroup level applications that do not reflect the overall goals and objectives of an organization.

This report discusses two current model architectures proposed and developed for GIS-T applications (several other models are discussed in less detail). The first model discusses a four tier architecture integrating data, activities, information technology and people into one integrated information system. The second model delves into more detail by discussing 15 different integrated servers combined into one GIS-T server-client architecture. These two models provide a first iteration of GIS-T applications. This report discusses a second iteration framework combining both of the above architectures to be used by Department of Transportations (DOTs) and Metropolitan Planning Organizations (MPOs). This framework combines the ISTEA management systems with attribute data, spatial data, transportation models, transportation analysis tools, procedures and people into one integrated server-client framework. Finally, a real-world application developed in one of the DOT districts in Florida using concepts of the enhanced framework is discussed. This system seamlessly integrates an ArcView GIS application with a knowledge based expert system (KBES) programmed in Visual Basic.

In 1991, one of the most important pieces of legislation was signed into law calling for coordinated efforts to collect, manage, analyze and store large quantities of transportation related data. The Intermodal Surface Transportation Act (ISTEA) required traffic monitoring and systems management monitoring of pavement, bridges, safety, congestion, public transportation facilities, and intermodal facilities. With these new management systems came opportunities to use existing technologies and resources to develop state of the art information storage, retrieval and management processes.

One of the state of the art tools used considerably in this arena is Geographic Information Systems or GIS. GIS, integrated with a Transportation Information System (TIS), more commonly called GIS-T[1], make up the foundation for current and future transportation management systems. These integrated systems will become the standard, replacing many existing stand-alone, subgroup level applications.

More complex database and GIS applications are being used to manipulate and manage large quantities of data. These applications are being used for congestion management systems, level of service (LOS) analyses, traffic count databases, pavement management applications, and roadway characteristics inventories, to name a few. The purpose of this paper is to discuss the design and implementation of a GIS-T application that manages and maintains data used to determine LOS, road improvements and road improvement costs. This GIS-T application was developed for both Metropolitan Planning Organizations (MPOs) and Departments of Transportation (DOTs). The application has been implemented within the Florida Department of Transportation (FDOT) and a MPO within the State of Florida. This paper uses as an example the implementation of the application for the FDOT.

Background

The GIS-T application was designed by considering first the needs and expertise of the end-user. Based on this premise, several application objectives were developed. In order to meet the objectives, the application should:

- be a truly integrated GIS-T application based on the definition of GIS-T,
- calculate LOS for an entire urban area or DOT district by individual roadway segment,
- determine necessary road improvements based on deficient segments,
- cost the improvements based on current construction, right-of-way, and preliminary engineering and construction inspection costs,
- perform all calculations based on accepted practices and procedures,
- be able to use data that currently exists within the State of Florida, and
- be as user friendly as possible and easy to maintain.

These objectives were used to develop the application outlined in the following sections.

Application Framework

Several GIS-T frameworks have been developed and implemented ranging from simple to more complex. The simplest framework includes only a database and a GIS application. Most complex frameworks involve client-server technology where as many as 15 servers may be used for various purposes.[2] The architecture chosen for this application can be considered to be medium in complexity and includes a GIS application and a separate, yet integrated TIS. The client-server framework was not chosen due to limitations in hardware in most governmental agencies.

The GIS-T framework chosen consisted of a GIS interface and TIS (sometimes called a knowledge based expert system or KBES[3]). This framework is illustrated in Figure 1. The most important feature about this framework was that both the GIS interface and the TIS interface had access to the same attribute data at the same time, therefore edits in one interface were carried over into the other. This eliminated the possibility of having two databases with different sets of data.

Application Design

After a framework was developed, the design of the application ensued. Figure 2 illustrates the general design of the application. As can be seen from this figure, ArcView (by ESRI) was selected as the GIS interface and Visual Basic (by Microsoft) was selected as the TIS interface. ArcView was selected since the roadway network obtained from the FDOT-Transportation Statistics Office (TSO), which is used by many agencies in Florida, was in Arc/INFO format. Also, ArcView is fairly easy to use and is widely used by the FDOT and local agencies within Florida. Visual Basic was chosen since it is easy to use and program. Visual Basic also contains the Microsoft Access database engine allowing it to handle large quantities of data efficiently and effectively. The integration of this application can be seen in the figure by the arrows going from the attribute data to both the GIS and TIS interface.

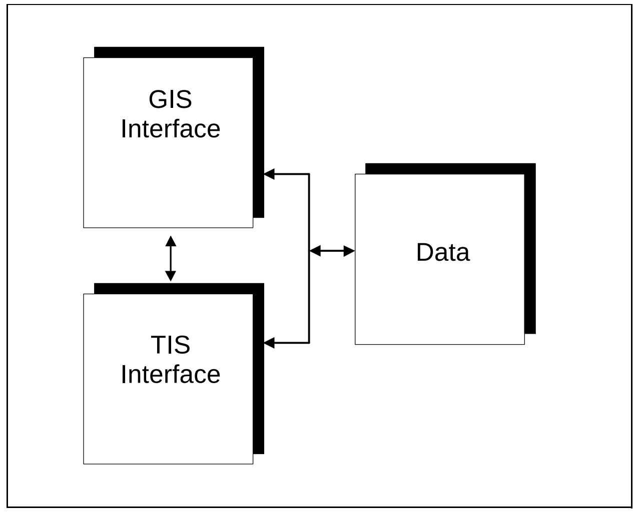

Figure 1: GIS-T application framework

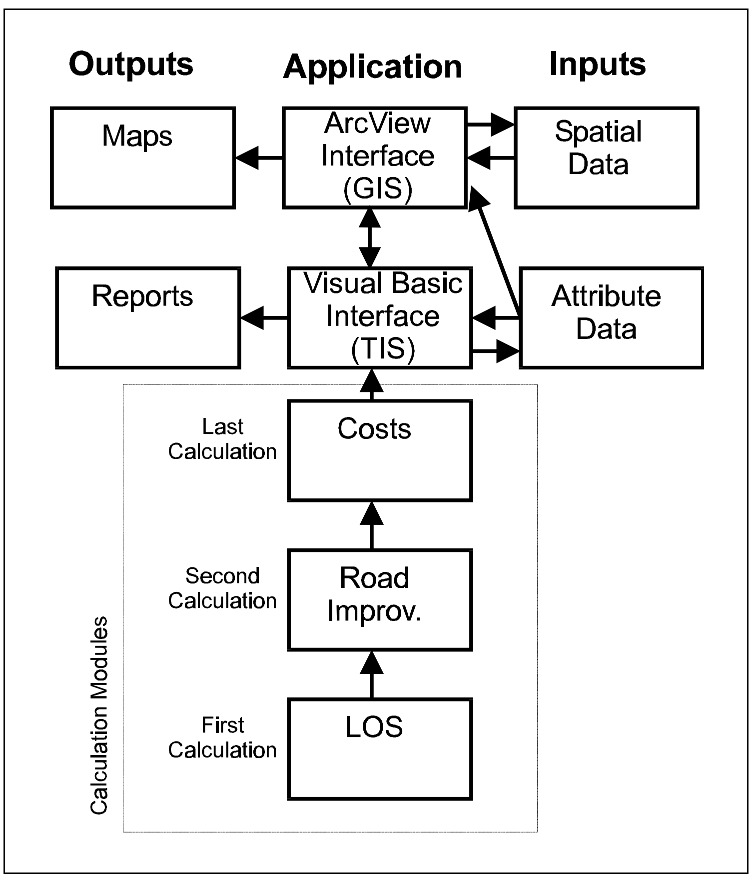

Figure 2: GIS-T application design

The calculations are included in the calculation modules section of the application. This module section can be considered like an electrical outlet in that new modules (such as future expansions to the application) can be "plugged in" with little or no disruption to the application. The calculation procedures are in order based on processing sequence. The LOS calculations must be completed first in order to estimate roadway deficiencies. After deficiencies are determined, the alternative improvements to mitigate the deficiencies are evaluated. Finally, after improvements are selected, they are evaluated for costs.

Methodology for LOS, Road Improvement, and Cost Calculations

The methodology for LOS used the procedures and guidelines outlined in the 1995 FDOT LOS Manual, which was developed from the 1994 Highway Capacity Manual (HCM). The FDOT has developed table generating spreadsheets based on procedures outlined in the 1994 HCM that estimate maximum service volumes for each LOS possibility (LOS A, B, C, etc.). The maximum service volume can be defined as the maximum hourly rate at which vehicles can be reasonably expected to traverse a uniform section of a lane or roadway during a given period under prevailing traffic, roadway, and control conditions at a designated LOS.[4] There are currently several different types of spreadsheets for facility type (arterials, freeways, and uninterrupted facilities) and area type (urban, transitioning, rural developed and rural undeveloped). Each of the facility types correspond to a chapter within the HCM. Each spreadsheet has the capability to analyze only one roadway segment at a time.

All of the spreadsheets were broken into components and re-programmed into the Visual Basic interface. An extensive quality check was done to ensure that the results from the application matched those of the spreadsheets and ultimately, the HCM. Each roadway segment record within the database had a field designating which LOS procedure (arterial, freeway, or uninterrupted) was used. From this, the program calculated service volume thresholds and compared the threshold to the actual peak hour volume on the roadway segment to determine a LOS letter grade. This letter grade along with the thresholds were stored into the database.

If a roadway operated below the LOS standard, the next road improvement that met or operated above the standard was calculated. For example, if a road operated at a LOS E and the LOS standard is D, the application found the next upgrade (e.g., a 2-lane to a 4-lane) that made the road segment operate at or above the LOS standard. Several assumptions were made during the upgrade process. For example, all of the improved roads were considered to be divided facilities with turnbays since this is common practice in the field assuming right-of-way is not constrained. Road upgrades were calculated by starting at the existing road type and progressing to facilities within the same class (e.g., arterials) with a greater number of lanes. If the maximum number of lanes was attained and the facility still operated below LOS standards, the next facility type with greater capacity was used. For example, if an 8-lane divided interrupted arterial did not operate at or above the LOS standard, the next upgrade would be a 4-lane uninterrupted facility. Eight-lanes were considered to be the maximum number of lanes for an urban arterial. It should be noted that the system does not take into consideration physical, policy, funding, or other constraints that may decrease the feasibility of an improvement. Therefore, careful consideration should be given to the outputs.

After improvements were estimated, costs were then calculated. The cost calculation included construction costs, preliminary engineering costs, construction engineering and inspection costs, and right-of-way costs. Figure 3 illustrates the general cost calculation procedure. The construction costs were estimated by obtaining a cost per centerline mile for the particular upgrade (e.g., 4-lane undivided to a 6-lane divided) as documented in *1994 Transportation Costs* produced by the FDOT Office of Policy Planning. This publication has generalized construction costs per centerline mile for several road improvement options. The preliminary engineering and CEI costs were taken to be a percentage of the construction costs. This is a common planning technique used within the State of Florida. Right-of-way costs were calculated by estimating the number of acres needed for the improvement and multiplying the acreage by the predominant land use cost (on the segment) per acre. The land use categories initially selected were residential, commercial and industrial. Although there are many different land use types, the three chosen typically repre-

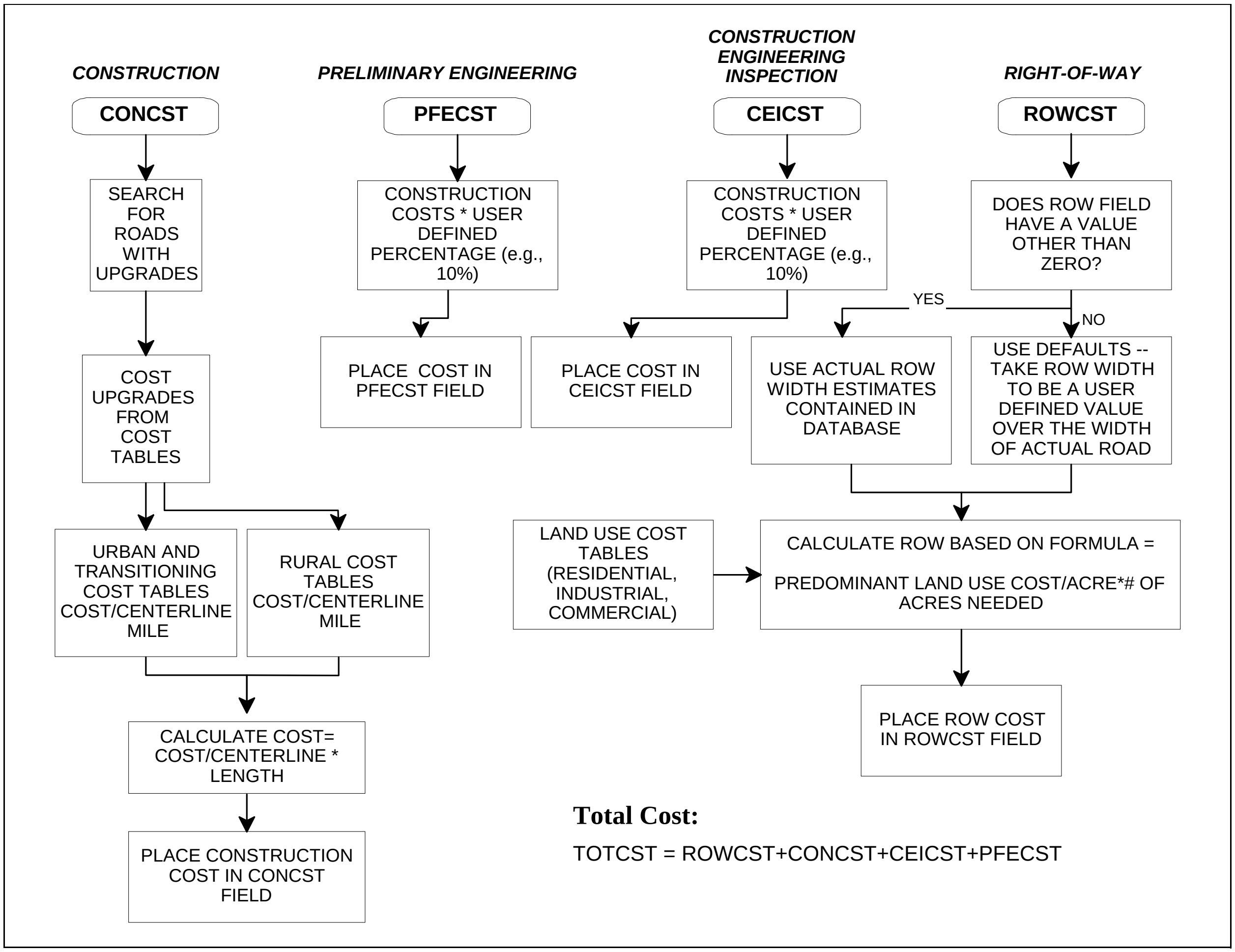

Figure 3: Cost calculations

sent the majority. However, further consideration should be given to areas with rural and urban areas. In these cases, land use categories should be added to reflect the difference within each area type. The right-of-way needed was estimated using a default cross-section width for each improvement or by actual right-of-way widths determined in the field. All of the costs were added together to estimate a total cost for the improvement per roadway segment.

User Interfaces

A graphical user interface (GUI) is the interface between the user and thousands of lines of programming code. The GIS-T application was designed to utilize GUIs for all if its screens. To minimize learning curves, the application only utilizes two main GUIs. The first GUI is the GIS interface and the second GUI is the TIS interface. Both GUIs are illustrated in Figures 4 and 5 respectively.

From review of Figure 4, it can be seen that two new menu items were added to the basic ArcView GUI: Transportation Analysis and Mapping. The menu item Transportation Analysis, when selected, executed (or loaded) the Visual Basic interface. This link made the application an integrated GIS-T application. The other menu item, Mapping, provided a fast, efficient way to create a map in ArcView. A series of questions were asked that when answered by the user, automati-

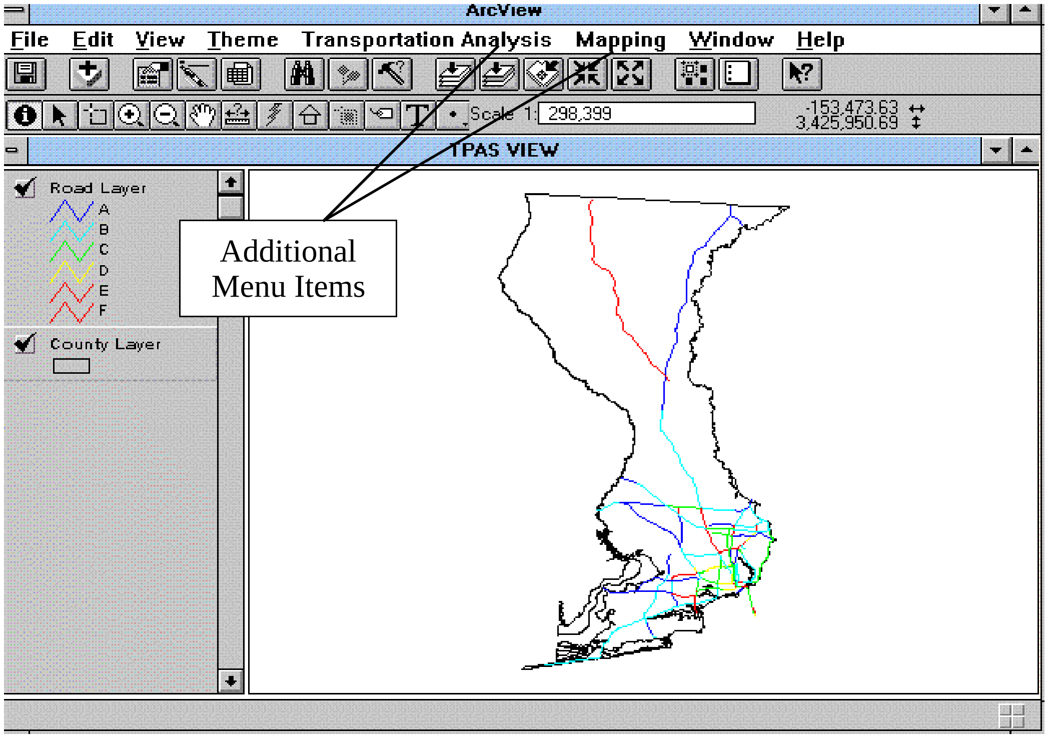

Figure 4: GIS (ArcView) interface

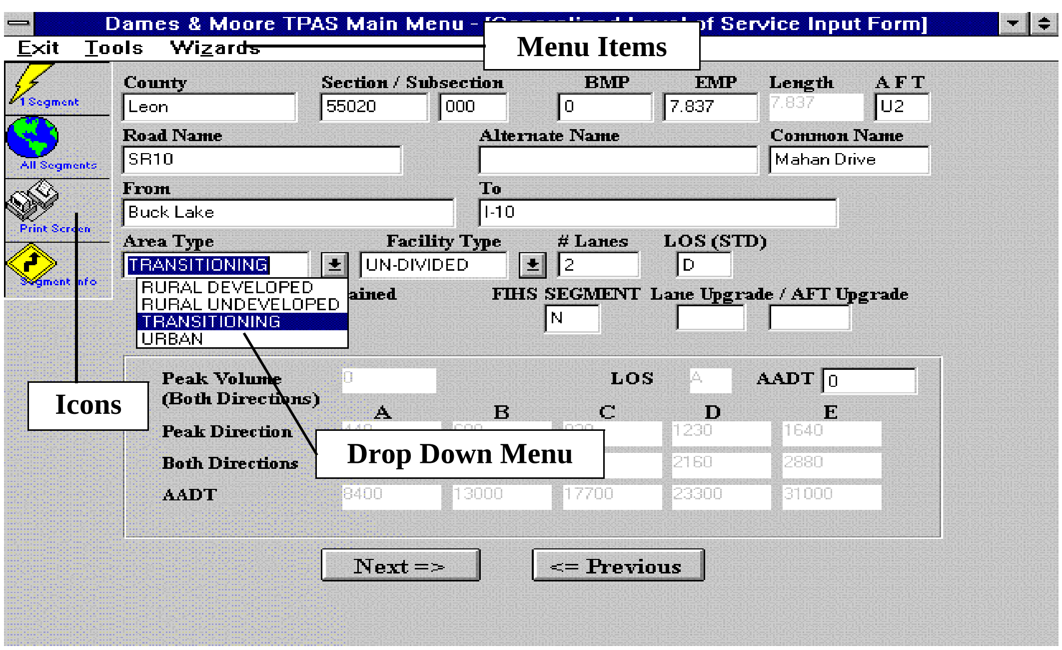

Figure 5: TIS (Visual BASIC) interface

cally generated a GIS map. A user who was not proficient in ArcView was able to generate maps quickly and professionally.

The Visual Basic interface contained three menu items: Exit, Tools, and Wizards. The tools' menu item contained several tools that performed various functions such as printing tabular reports and searching for specific records. The Wizards menu item contains two wizards: a LOS Wizard and a Data Warning Wizard. These Wizards quickly, easily and efficiently guided the user through processes that may be complicated for first time users. The Visual Basic interface contained all of the data for each segment. The LOS, road improvement and cost equations are calculated in this interface. Data were editable by entering the information directly or by clicking on drop-down menus as illustrated in Figure 5. One record at a time could be calculated or the entire database could be calculated at one time. The program took approximately three to five minutes to calculate 600 records on a Pentium based computer.

GIS-T Application Comparative Analysis

Implementing the GIS-T application for the FDOT involved collecting and analyzing data for approximately 600 roadway segments traversing 16 counties. The GIS-T application was not only used to manage FDOT data but was also used by the FDOT to verify the data and calculations used for long range plans developed for state roads by the local agencies. Considering this use, the newly developed application was validated by applying it to estimate improvements and costs developed for the *2020 Panama City Long Range Plan* completed in 1996.

This Plan was chosen since an integrated GIS-T application was not utilized during its development. Also, Panama City is one of the larger urbanized areas within the FDOT District that the application was installed. Data was obtained from the Panama City MPO and entered into the application. The data used for this comparative analysis reflected the data used for the development of the Plan except for future volumes. The Plan used 2020 model volume projections which were not obtained during this comparative analysis. Instead, historical growth rates were used to estimate 2020 volumes. This will introduce some differences between the improvement estimations, however, still will provide a good validation procedure.

The first element to be compared was road improvements. The Plan used LOS thresholds to determine road improvements. These thresholds were obtained from the FDOT *LOS Manual* using default input values for PHF, K-factors, D-factors, etc. Road improvements were estimated based on the next facility improvement that had a maximum volume threshold that was greater than the actual volume of the roadway. Only state roads were considered in this comparative analysis since the data obtained for state roads were more accurate than for off-system roadways. The results of the analysis concluded that out of the 26 roadway segments, the application estimated the correct road improvement 17 times, or 65 percent. Most of the road improvements not designated by the application were in rural areas of the county. This can be attributable to the fact that in most rural areas, adequate data is not available to determine traffic growth patterns. Therefore, the rural traffic counts used to estimate the 2020 volumes may have been somewhat inaccurate, thus introducing error in the future year volume estimates.

The second element to be compared in this analysis was cost of the road improvements. The methodology used to estimate costs in the Panama City Plan Update was different from what was used in the GIS-T application. The major difference was in the right-of-way costs. The Panama City Plan Update took the right-of-way costs to be a percentage of the construction costs depending on area type. In less developed areas, the right-of-way costs were taken as one-half of the construction costs. In highly developed areas, right-of-way costs were taken to be 125 to 150 percent of the construction costs. As mentioned earlier, the GIS-T application estimates right-of-way costs by first estimating the acres need for the improvement and multiplying it by a generalized cost of the most predominant land use adjacent to the roadway. A general cost per acre for all land uses in Panama City was used for this analysis. This data was obtained from the Panama City MPO.

Preliminary engineering and CEI costs were estimated in the Panama City Plan Update by using a variable percentage of construction costs. If the construction costs were less than $500,000, 18 percent was used; between $500,000 to $2,000,000, 14 percent was used; and greater than $2,000,00, 10 percent was used. As mentioned earlier, the GIS-T application also calculates CEI and preliminary/final engineering costs. For this analysis, CEI costs were taken to be 5 percent of construction costs and preliminary/final engineering costs were taken to be 10 percent of construction costs.

Construction costs used in the GIS-T application for this analysis were taken from the FDOT *1994 Transportation Costs* publication and from the Panama City Plan Update document. The comparative results concluded that the overall percent difference of the total costs was six percent. The largest percent difference was -59.3 percent and the smallest percent difference was 1.9 percent. Considering the two different methodologies used to estimate the costs, they were relatively similar. Most of the error was attributable to the variation in lengths of the segments. It was difficult to geographically reference the Plan Update network to a GIS. There were several inconsistencies with the lengths of the segments in the Plan Update and with the geographic file. Also, there were several roadway lengths in the Plan Update that did not correspond to the straight line diagrams. Variations in roadway length will affect the construction cost estimation, which will affect CEI and preliminary/final engineering costs. Also, the variable percentage of costs for CEI in the Plan Update also added to the variation in costs between the two methodologies.

Conclusions

This new application provided an efficient and effective alternative to current analysis techniques. This application transformed spreadsheets into a fast database program that was able to process hundreds of records in a fraction of the time. Also, this application provided an integrated geographic reference to easily map the data immediately after the database had been updated and recalculated.

This application can also be used as a tool to quickly and effectively develop or validate the highway element of long range transportation plans. From the Panama City example, it can be seen that the application can automate part of the long range transportation plan process and still be accurate. If model volumes had been used in the validation procedure instead of historical growth rates, the differences between the application and the Plan would have decreased further.

Considering the above, it was the conclusion of this research that the new application was an effective and efficient tool to be used in determining LOS, road improvements and road improvement costs. These procedures can be done as a stand alone process or as part of a long range transportation plan. Not only did it drastically reduce the time spent on tasks, but it accurately calculated road improvements and costs based on applicable procedures and guidelines. This application can free-up precious transportation agency resources to perform tasks of greater importance. With the funding shortfalls of most agencies worsening, it is imperative that remedial or repetitive tasks are streamlined so that minimal resources are devoted to them. GIS and database management tools are the only effective way to streamline these types of tasks.

Future Enhancements

There are several enhancements to this application that will make it more effective. The following list several enhancements that are being further studied to improve the application.

- Transportation Model Interface - the application should have the capabilities to interface with the local (Florida) FSUTMS models as well as to TRANPLAN or MINUTP.
- Traffic Counts Database and Calculations - the application should have the capability to project, either by historical growth rates or model volumes, traffic volumes into the future to estimate long range needs. This should be completed automatically with the modeling interface.
- Multi-Modal Compliant - the application should be able to manage and maintain attribute and spatial data for multimodal features such as bicycle paths, sidewalks, transit, and park-n-ride lots. Queries and other reports should be produced showing this data.
- Road Improvement Alternative Selection Process - a prioritization procedure should be in place to estimate, after road improvement alternatives are estimated, which roadway segments should be improved first. The prioritization procedure may include levels of congestion, multimodal service, regionally significant roadway, etc.
- Internet Link for Public Involvement - an Internet link should be established illustrating goals and objectives, short-term, intermediate, and long-term roadway improvements, costs of needs plan, revenue shortfalls, etc. Since, this technology is changing rapidly, it is imperative that one constantly stays abreast of the latest developments.
- Linkages to Other Management Systems - the application should be able to share data between the safety, pavement and other management systems.

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Congestion Management Planning Using the Transportation Analysis Database

Erin Vaca and Stephen Decker, Cambridge Systematics, Inc.; and Jose Luis Moscovitch, San Francisco County Transportation Authority

Abstract

The San Francisco County Transportation Authority (SFCTA) is responsible for implementing, updating, and monitoring the state of California-mandated Congestion Management Program (CMP) for the city and county of San Francisco. The SFCTA developed a geographic information system- based transportation analysis database (TAD) system designed to evaluate elements of the CMP as part of its biannual monitoring, updating, and reporting process. CMP elements include land use impacts related to travel demand, transportation system monitoring and reporting, and transportation system intersection and roadway deficiency analysis.

The Transportation Analysis Database was designed as a spatial framework for local and regional transportation and land use data, a tool for improving consistency between local and regional data, and as a platform for the incremental development of a future GIS-based transportation model system.

The SFCTA intends to use the TAD to evaluate not only specific CMP elements but also evaluate the transportation impacts of large land use development projects, the land use and transportation impacts of proposed transportation system improvements identified as part of Major Investment Studies and Light Rail Corridor Studies, and the travel demand impacts of potential highway closures. The TAD incorporates data from several local and regional sources including:

- Travel forecasts from Metropolitan Transportation Commission's regional travel model:
- Socioeconomic forecasts developed by the Association of Bay Area Governments;
- Commuter travel behavior collected by the Bay Area Air Quality Management District;
- Journey to work information from the Census Transportation Planning Package;
- Transit ridership estimates for BART, CalTrain, SamTrans, MUNI, and AC Transit; and
- Spatial data derived from Census TIGER files (including census tracts, blocks and traffic analysis zones).

This analysis tool has been applied to evaluate the potential travel and socioeconomic impacts of constructing a downtown Baseball Stadium for the San Francisco Giants, to identify the appropriate corridor alignment and travel demand impacts of proposed light rail in the Bayshore Corridor of San Francisco, and to identify the travel impacts of closing the Central Freeway in the downtown of San Francisco.

Michigan's Congestion Management System

Cynthia VonKlingler, Michigan Department of Transportation

Abstract

Michigan's Congestion Management System has been developed concurrently with the development of the six management systems that were mandated by the Intermodal Surface Transportation Efficiency Act of 1991. While the development of the transportation management systems is no longer required, Michigan chose to continue the development of these 6 management systems. From the outset, the effort to develop transportation management systems has been seen as an integral part of several major developmental efforts within the Department including integration of isolated data bases, migration from mainframe operations to distributive data processing in a client/server environment, examination and re-engineering of major business processes within the Department, and enhanced coordination among Michigan transportation agencies through sharing data and meeting the combined information needs of this diverse group of users.

The Congestion Management System has been designed to aid users in identifying specific locations where congestion occurs or is expected to occur. The TMS data base incorporates historic traffic data and future traffic forecasts from the Statewide model and urban area models. The system also provides access to historic and forecast socioeconomic data and information from the Census. Socioeconomic data is stored at both the TAZ and County levels. The CMS also provides summary statistics for user-selected routes or for specific geographical areas of the State.

The Congestion Management System produces a list of viable candidate projects as input to the programming process. It also includes numerous performance measures and indicators that can be used to measure progress towards meeting the goals and objectives of the State Long Range Plan and long range plans of regional and metropolitan planning agencies.

Along with describing the features and uses of the Congestion Management System at its current development stage, this paper and presentation will include an evaluation of the development effort including which methods were successful and areas for improvement. The discussion also will include plans for the future refinements to the application.

Michigan's Congestion Management System (CMS) has been developed concurrently with the development of five other management systems that were mandated by the Intermodal Surface Transportation Efficiency Act of 1991. While the development of a congestion management system is no longer required outside of Transportation Management Areas (TMAs), Michigan chose to maintain a statewide focus for the development of these 6 management systems including the CMS. From the outset, the effort to develop transportation management systems has been seen as an integral part of several major developmental efforts within the Department including:

- integration of isolated data bases,
- migration from mainframe operations to distributive data processing in a client/server environment,
- examination and re-engineering of major business processes within the Department, and
- enhanced coordination among Michigan transportation agencies through sharing data and meeting the combined information needs of this diverse group of users.

The Congestion Management System has been designed to aid users in identifying specific locations where congestion occurs or is expected to occur. The supporting data base incorporates historic traffic data and future traffic forecasts from both the Statewide model and urban area models. The system also provides access to historic and forecast socio-economic data and information from the Census. Socio-economic data is stored at both the traffic analysis zone and county levels.

The CMS provides summary statistics and performance measures for user-selected routes, by geographical area, or by any of several road classification systems. Many performance measures and indicators are available and can be used to measure progress towards meeting the goals and objectives of the State Long Range Plan and long range plans of regional and metropolitan planning agencies.

The CMS application is integrated with five other management systems, collectively known as the Transportation Management System or TMS. Although each TMS subsystem is, in some sense, an independent entity and can operate independently for highly specialized tasks, users realize the greatest benefit when the information provided by all subsystems is applied to develop coordinated solutions to transportation issues, challenges and problems.

To visualize how the CMS can be used in conjunction with other subsystems to improve transportation systems in the State, some background information on the TMS will be useful. The next section of this paper presents some history and describes the foundations of the TMS.

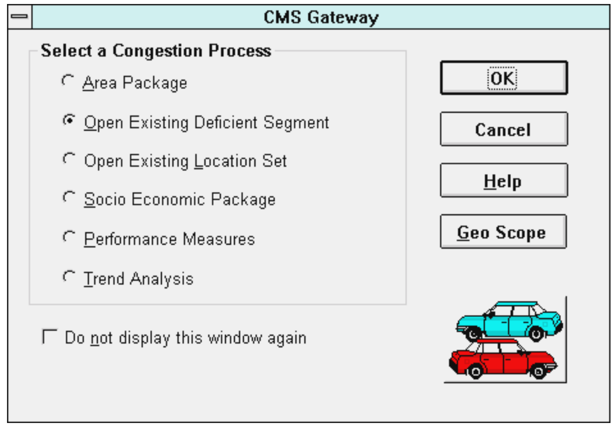
The Foundations of the TMS Application

In Michigan, the Bridge Management System (BMS), the Congestion Management System (CMS), the Intermodal Management System (IMS), the Pavement Management System (PMS), the Public Transit Management System (PTMS), and the Safety Management System (SMS) are collectively known as the Transportation Management Systems or *TMS*. All six subsystems are supported by an Oracle data base consisting of over 900 data and code tables containing approximately 5 gigabytes of data. Currently, the database contains inventory attributes and operational characteristics for all State Trunkline routes (9602 route miles) and National Highway System routes (4720 route miles) and will be expanded to include all federal aid roadways within the State. This fully integrated common data repository provides a storehouse of historical and forecast data and information needed to support sound investment decisions.

The TMS user interface is a Powerbuilder application that will continue to be enhanced as business operations and user needs grow and change. Providing access to data and information about roads, bridges, ports, transit fleets, border crossings and all other components of the transportation system in Michigan, the application brings a vast store of information to users throughout the State.

All users have access to all subsystems, although user rights are aligned with job functions so that sensitive or highly specialized data are available only to those who are trained in it’s use. For example, all users have access to socio-economic information including forecasts; all historical inventory and operational characteristics of roadways; and base year model runs, long range plan year model runs and 2 or 3 interim year model runs for all modelled areas in the State. Access to specialized model runs is restricted to core CMS users who fully understand travel demand models and the application and limitations of raw model outputs.

Each subsystem includes a Gateway, which is a starting point to help users find information or begin a process. The Gateways, combined with "bubble help" and other on-line help documents aid individuals in becoming proficient users of the vast data resources represented in the TMS database.

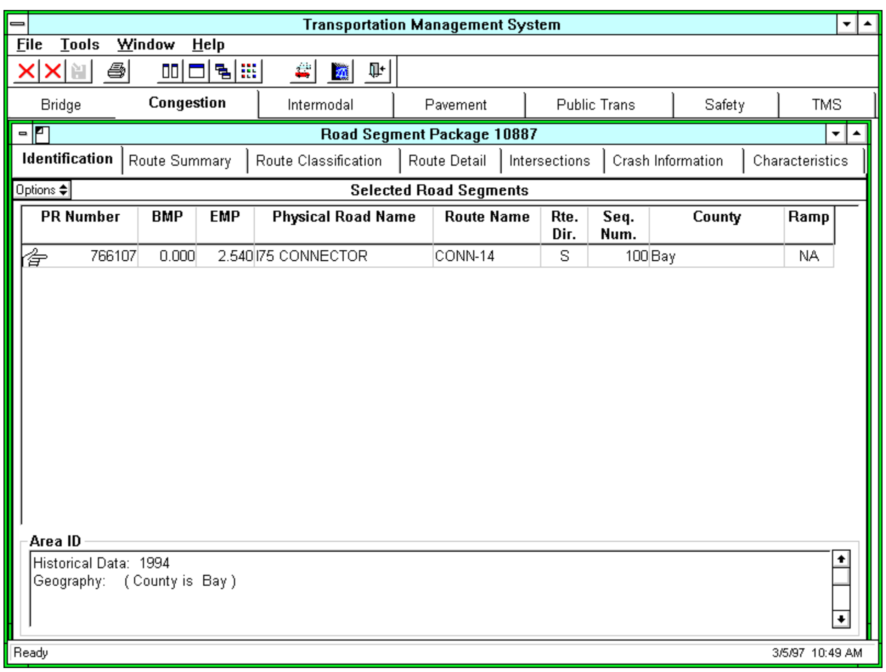


The CMS Gateway is a starting point for navigation through the Congestion Management System.

During system development, displays of information (screens) were grouped into *packages* such as the Road Segment Package shown above. Packages are designed to function similarly across subsystems so that users encounter a consistent method to complete tasks and solve problems. This is especially helpful for users who will primarily use one subsystem, but occasionally need to access information from another subsystem. Through these information packages, the TMS brings a wide array of information to users in many departments and agencies across the State.

Some of these packages such as the Transportation Analysis Notebook are shared across subsystems. The Transportation Analysis Notebook provides a means for users to record potential strategies for solving a problem and provides a means for cross-referencing to related notebooks. Users have access to these notebooks from anywhere within the TMS. This feature supports coordinated development of Transportation Improvement Programs and Long Range Plans.

Many of the packages display information in a spreadsheet format, making common spreadsheet functions readily available to users. Users can reorder columns, perform sorts and filters, export to



The Road Segment Package consists of 7 tabs or screens of information. The Tab Paradigm provides a common user interface across subsystems.

other applications, and create graphs easily within the TMS. These features are easy to invoke using a drag and drop operation or a right mouse click and making a few selections from pop-up windows within the application.

Major Features of the Congestion Management System

The functions of the seven core packages within CMS are described in the table below. As information needs change and expand, these packages will likely be restructured and enhanced.

Geographic Scoping and Filtering

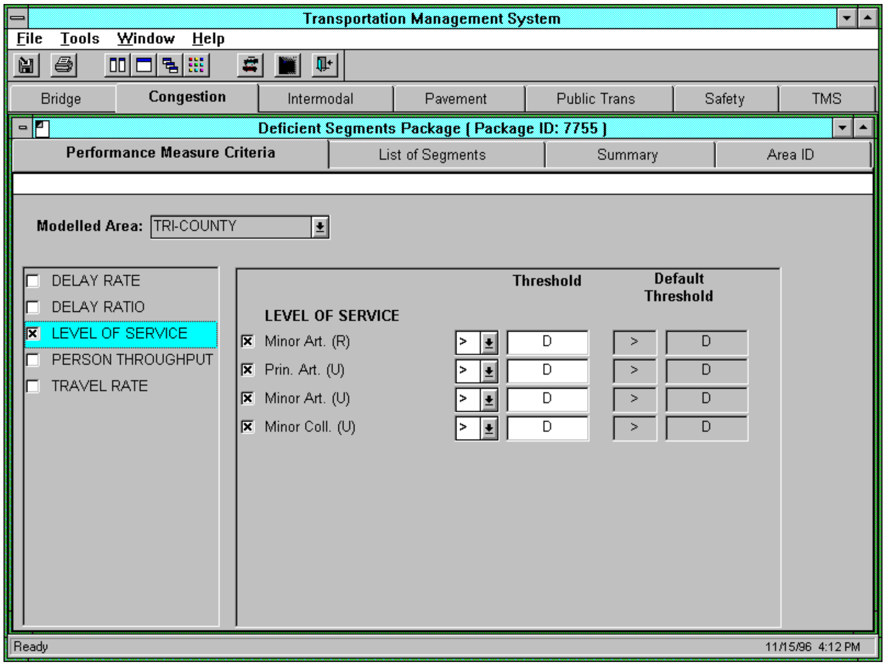
Upon entering the CMS, the user chooses a geographic scope for their query, a layer of the transportation system to focus on, and whether to view historic or modelled data. Geographic scopes include statewide, district, urban modelled area (MPO), county, and corridor or other type of sub-area. This initial narrowing of the query results in a pared down list of routes from which the user can target a specific query to the TMS database and see results of the query displayed in the Road Segment Package, the Deficient Segments Package or the Performance Measure Package.

Choosing Performance Measures and Thresholds for Acceptable Performance

The CMS identifies deficient locations through the Deficient Segments Package. Segment-level performance measures, such as Level of Service (LOS), Travel Rate and Delay Rate are used

Congestion Management System Packages

Area Package	• view socio-economic data at the traffic analysis zone level • view a list of routes within a selected area and identify dual routes • choose routes (define query parameters) before entering the Road Segment Package or Deficient Segments Package or Performance Measure Package.
Road Segment Package	• view operational and physical characteristics for roadways at both detailed and summary levels. • view historical and forecast roadway information
Deficient Segments Package	• choose performance measures to be used to identify deficiencies and alter thresholds • view congestion deficiencies based upon the user’s choice of performance measure and threshold • view a summary of deficiencies • identify and save a location for further analysis
Location Builder Package	• propose improvements to resolve deficiencies and associate preliminary costs with each • present a list of all facilities associated with the selected location • summarize preliminary costs to resolve deficiency at this location
Socio-economic Package	• view Census Journey-to-Work information by county • view county-level population and employment history and forecasts • view Census data at Statewide zone level
Performance Measure Package	• view high level trends in performance
Trend Analysis Package	• view growth of operational characteristics for the State, by county or by district. • apply a growth rate to operational characteristics • perform simple linear regression



Deficiencies can be identified using several performance measures. The user selects one and adjusts the thresholds as desired.

within this package to identify congested road segments. Policy-approved thresholds for acceptable level of performance are established by the MPO for roadways within the Metropolitan Area Boundary (MAB). In areas outside of a MAB, the thresholds are established by the agency with jurisdiction over the roadway. These policy-approved thresholds are stored in the TMS database and are displayed as *Default Thresholds* on the **PM Criteria** screen.

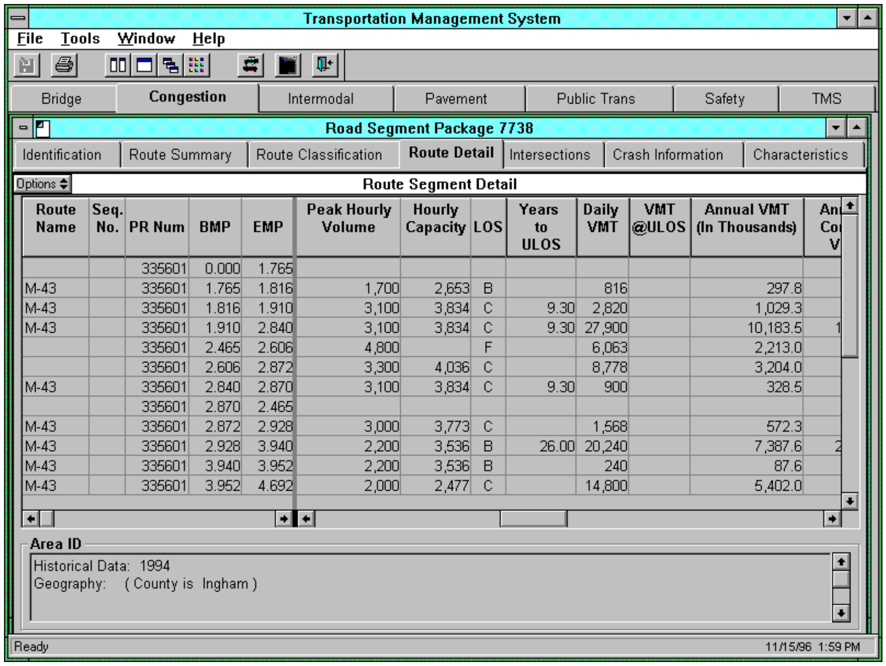
The CMS allows individual users to adjust these thresholds for a particular analysis and save the threshold settings with the analysis in a *Transportation Analysis Notebook* so that the analysis can be reconstructed at a later date.

Identifying and Scaling the Magnitude of Deficiencies

Once the performance measures are chosen, the CMS produces a **List of Segments** within the user- defined geographic area and year. The **List of Segments** will show either all road segments or deficient segments. *Additional Lanes* and *Additional Lane Miles Required to Resolve Deficiencies* help the user determine the magnitude of deficiencies. From the **List of Segments** screen, the user can use the sorting and filtering functions and can select a set of segments for further inquiry into possible causes of the congestion or for summarization. The **Summary** screen within the Deficient Segments Package, shows the distribution of *Miles*, *Lane Miles*, *VMT*, *Commercial VMT*, *VHT* and other performance indicators by Levels of Service.

Viewing Roadway Attributes and Operational Characteristics

Historic, current year and forecasted roadway attributes can be viewed through the Road Segment Package. The elements displayed vary, depending upon whether the user is viewing historic data or forecasted (modelled) data. The user can compare data for different years by opening additional packages and using the standard Windows features to navigate between or among opened

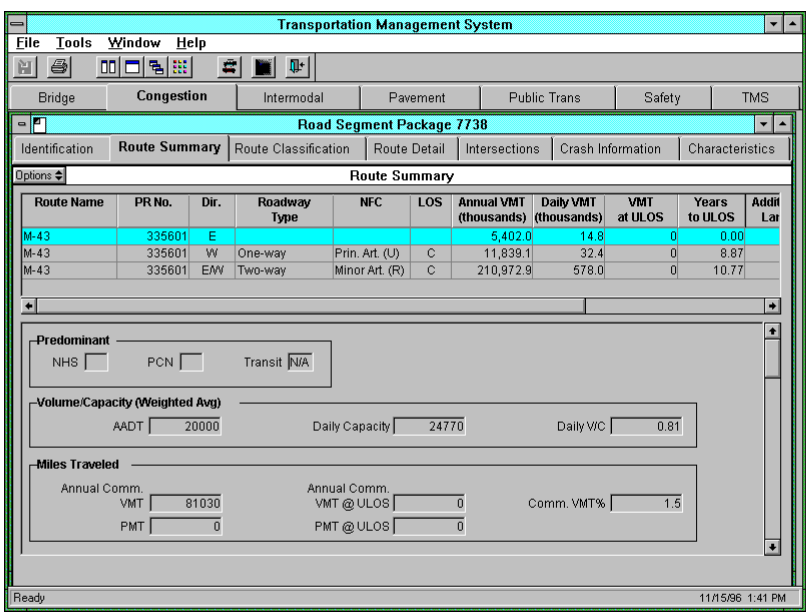


The Route Detail Screen

packages. The **Route Detail** screen presents information on a segment level. This is useful for identifying bottlenecks that may be causing congestion on adjacent or upstream segments.

The **Route Summary** screen presents aggregated information route by route for the user's selected roadways. Through this screen, comparisons are made between the roadway as a whole and those segments operating at an unacceptable Level of Service (e.g., Total Commercial VMT and Commercial VMT at Unacceptable LOS).

Roadway use constraints are also presented as Intermodal Restrictions (including minimum num-



The Route Summary Screen

ber of lanes; minimum lane width and shoulder width; and minimum and maximum ADT, commercial ADT and % commercial). The magnitude of a congestion problem is expressed as a weighted average of Years to Unacceptable LOS and Additional Lane Miles Required to Resolve Deficiencies. This screen provides a means of comparing two or more roadways (peer group analysis), as well. Mobility or accessibility problems can be investigated further by using the **Route Classification** screen. The **Route Classification** screen presents aggregated information by "system slice." If, for example, providing efficient access to an intermodal terminal is a problem, the user can summarize roadway attributes by Roadway Type or compare operation of roadways included in the Priority Commercial Network (PCN) to those that are not.

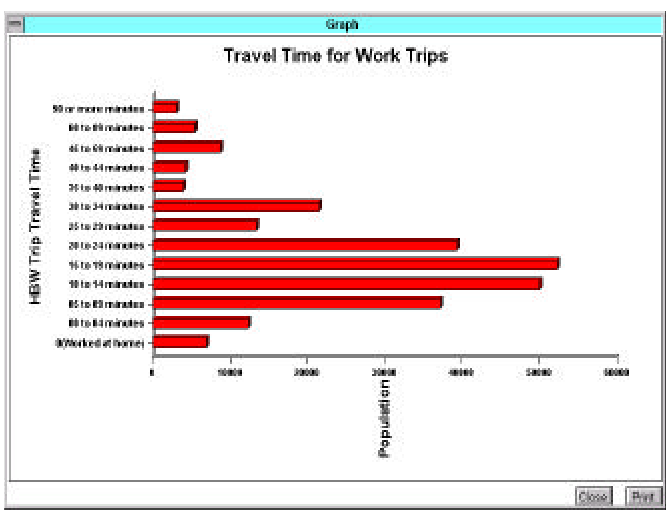
Analysis of Alternatives

Once a deficiency has been investigated through the Road Segment Package and Deficient Segments Package, the user can select segments to include in a proposed project and carry this selection of road segments to the Location Builder Package. The Location Builder Package presents a list of facilities (intersections, bridges, etc.) that are associated with the deficient roadway so that costs for modification of these associated facilities can be included. Costing tables used for this process contain rough unit and/or fixed costs for a variety of solutions and allow for regional variances in costs. The user has the option to use the cost tables or to enter a cost estimate of one's own.

Each solution package can be saved to the TMS database and retrieved from a list of all such locations by any user of the TMS.

Viewing Socio-economic/Demographic Information

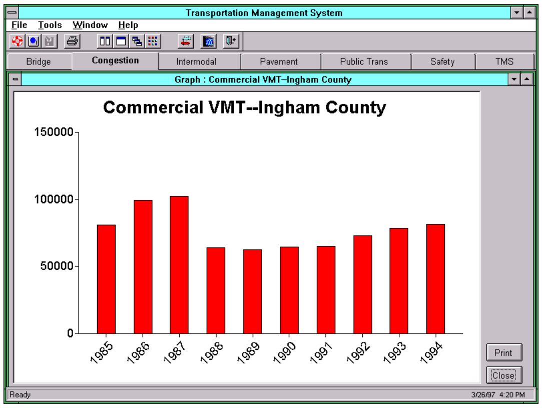
Current and forecasted population and employment characteristics are displayed by Traffic Analysis Zone through the Area Package screens. Socio-economic data is available for the Statewide zone configurations and for each urban area's zone configuration. In addition to zonal data, selected data from the Census is available for viewing at the county level. This Census information is presented in the Socio-economic Package along with selected socio-economic forecasts of employment by industry and population by gender and age developed by the University of Michigan using the REMI (Regional Econometric Modelling, Inc.) model.

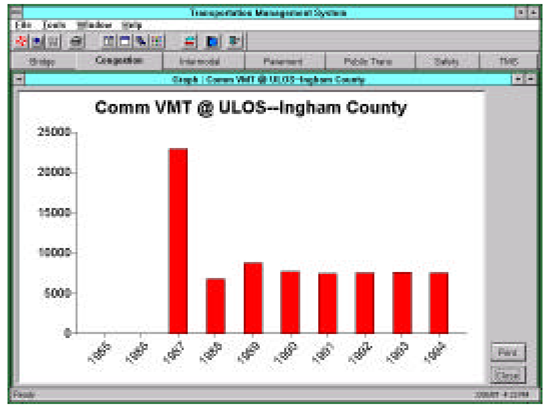


Spreadsheet displays are transformed into graphs with a few mouse clicks.

System level Performance Measures and Trends

New planning initiatives such as outcome-based assessment and performance-based planning require the availability of a broad range of data items so that progress toward objectives can be monitored on a regular basis. A broad range of performance measures is also needed to adequately evaluate the costs and benefits of proposed alterations to the transportation system. Without such measures, dollars cannot be effectively targeted toward





meeting transportation needs in an area in a balanced equitable manner.

A wide variety of performance measures and trends can be displayed through the CMS to identify and quantify mobility and accessibility problems or achievements. From the start, CMS development efforts focussed on supporting a variety of performance measures and performance indicators that would benefit users at all levels and that would be sensitive to improvements in efficiency (improved person movement and goods movement). This effort has resulted in a performance framework within CMS that, in one sense, stretches the limits of currently available data. The effort also is setting direction for future data collection priorities. Where data resources are weak, the CMS uses default factors in performance calculations. While using defaults does compromise the accuracy of information, on-line “bubble help” documents all system calculations so that users know which calculations use default factors. When presented with new measures, users can begin thinking about how they will use new measures and set priorities for data collection to support those that are most meaningful.

Other types of readily available historical information have been incorporated into the CMS Trends Package. These include total VHT, VMT, Commercial VMT, Lane Miles, Person Miles of Travel and accumulations of each of these at unacceptable Level of Service. A ten year history by county is available for these statistics. Corresponding forecasts are developed on an annual basis and can be displayed within the trends package. The user also has the option of applying simple linear regression to the historical data or applying a growth rate to project these statistics into the future.

The figures at the left compare the change in Commercial VMT to the change in Commercial VMT operating at unacceptable level of service (ULOS) for urban interstates in Ingham County. Commercial VMT at Unacceptable LOS remains stable in recent years while total Commercial VMT increases, translating to improved service to commercial traffic in this county.

Plans for Future Enhancements

The environment in which the TMS will be used is continually changing as it was when the original visioning exercises began over 4 years ago. Current changes affecting operations within the Department include implementation of a new MPO planning process, a new project development process, significant downsizing and a major decentralization of operations and staff. All of these developments will have some impact on user information needs and consequently on the direction of system enhancement.

Our first step is to gain more experience in using the CMS components of the TMS in the decision processes that support business operations at MDOT. The current TMS tool provides key pieces of information that help to identify problems and possible solutions. However, other information, such as detailed comparisons of alternatives, must be obtained from sources other than the TMS. As the practice of integrating solutions that resolve roadway deficiencies through ITS, modal and other types of actions matures, the TMS tool can be evaluated and future enhancements identified. Likewise, as more users gain experience in using the application and new types of information such as CMS performance measures, their feedback will provide direction for future development.

In the meantime, work will continue on cleaning up and filling out data sets, implementing the road referencing system (PR numbers) and expanding data sets to include all federal aid routes in the State. Generalized default factors for local areas, such as auto occupancy rates, will be refined as new data becomes available.

Evaluation of the Development Effort

Management vision of what the TMS and CMS could be was without question ambitious. Visioning workshops set the pace and expectations for an aggressive development effort that would change the way business is conducted at MDOT. The potential to reach that vision remains, but even after more than 3 years of design and development work, there are more milestones to pass. With continuing changes in technology and in the organization and business processes at MDOT, the horizon at which we are aiming continues to recede even as major strides are made toward reaching that vision.

The CMS vision included providing information support for diverse functions from detailed alternative analysis to assembling the annual program to surveying statewide trends in congestion for presentation to the State Legislature. We now realize that this scope was too broad to accomplish, considering available resources and the lack of actual experience with the reengineered business process. The currently available CMS functions support basic information needs of a few user groups. Enhancements will be designed and developed as users gain experience in using the system within the framework of the new business processes.

Data availability, reliability and compatibility problems continue to surface and are resolved as they arise. Since the TMS database does not replace all of the isolated legacy databases, there is still work to be done replacing or building interfaces between other systems and the TMS. Until the data base and these interfaces mature, data extraction, conversion and loading processes will continue to feed the TMS and consume more staff resources than originally anticipated.

Hardware and software (operating system) requirements of the TMS continue to grow as the system becomes more complex. Currently, the roll-out pace is dependent upon the client's ability to convert to a Windows NT operating system, running on a PC with at least a Pentium 90 processor with a minimum of 32 megabytes of RAM and 1 gigabyte of disk space. The CMS is currently available to 15 core users and an additional 30 general CMS users. The CMS subsystem is also available to users of the other 5 subsystems. Forty to fifty transit agencies have access to CMS through their PTMS connection.

The vision for the TMS (and the success of any system-wide integrated database) is predicated on having a common road referencing system in place with all legacy files converted to this common system. This project chose to use the Michigan Accident Location Index (MALI) road referencing system developed in the early 1970s, adapting and expanding it to meet the requirements for this application while supporting the continued use of the scheme by the Michigan State Police and local enforcement agencies for accident reporting. That effort has progressed more slowly and required more resources than anticipated, but is now being adapted for inter-agency use through a statewide Framework Project.

The vision for the system was also predicated on having true GIS functionality included. At the start of the TMS development effort, GIS products that could operate in the three-tiered object-oriented environment of the TMS were not commercially available. This development lag had significant impact on our ability to realize our vision for the TMS. The TMS release scheduled for late May- June 1997 will include mapping capabilities for displaying system information.

Despite these stumbling blocks, what has been accomplished within 2½ years of development is remarkable. From the CMS perspective, socio-economic and traffic forecasts are readily available to a much broader group of users. Likewise, historical trends in VMT, Commercial VMT, vehicle hours of travel and person miles of travel are readily available, with graphs of these trends available with a few mouse clicks. A range of performance measures are available for identifying deficient locations. At a higher level, system performance indicators for the National Highway System, the Priority Commercial Network, various roadway types and most National Functional Classes enable users to view the extent of congestion in Michigan from many perspectives. Preliminary cost estimates can be applied to proposed solutions to congestion problems. Impacts of proposed solutions can be compared within a comprehensive performance measure framework that is aligned with State Long Range Plan goals and objectives.

Additional information about Michigan's TMS and the Congestion Management System is available from:

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Congestion Management System/Mobility Management Process: The South Florida Experience Through the Eyes of the Broward County Metropolitan Planning Organization

Enrique R. Zelaya, Broward County, Florida

Abstract

Last August and consistent with federal legislation, the Broward County Metropolitan Organization established a Congestion Management System and developed the first Congestion Management Plan for the area. This Plan is the result of a 20-month effort during which the system was developed and its first cycle completed. The system was developed through cooperative efforts with the Florida Department of Transportation and it has become the prototype for the metropolitan areas in the State of Florida.

The purpose of the Broward County Congestion Management System (CMS) is to establish and maintain a periodical process that provides information on transportation system performance and alternative strategies to alleviate congestion and enhance the mobility of persons and goods, with particular emphasis on less capital intensive options. It is designed to assist decision-makers in selecting cost effective actions in order to improve the efficiency of the County's transportation network.

A CMS task force has been formed, consisting of a group of qualified individuals representing agencies that have a relevant role in providing solutions to traffic congestion. This interagency technical group meets on a regular basis. A public involvement process has also been developed. A workshop to introduce the system was conducted, with the participation of elected officials from the League of Cities. As congested corridors were identified and specific mobility strategies were being formulated, the task force prepared presentations for those municipalities with the highest degree of traffic congestion. Presentation of a CMS video, and a priority list of potential improvements were made at city council meetings.

The plan consists of a list of evaluated strategies, prioritized for each identified congested corridor. This plan is also being utilized as a resource document for the update of the Transportation Improvement Program (TIP) priority list, as well as, the Long Range Plan.

A GIS data base and map series have been prepared to facilitate the monitoring of the performance for the roadway and transit networks.

The Balance of Decision Support: MDOT's Intermodal Management System

Marty Lontz, Michigan Department of Transportation

Abstract

Prior to passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the Michigan Department of Transportation (MDOT) dealt with intermodal decision making using mode specific tools defined by appropriate federal or state agencies. ISTEA mandates, now recommendations, provided the impetus to find a means by which these varied methods could be, if not standardized, made common enough to allow comparison of the needs of one mode with those of another. The Intermodal Management System (IMS) allows planners and managers to balance issues required to efficiently make effective decisions leading to seamless connections for nonmotorized, rail, road and waterborne people and goods.

The first balance struck is between modal systems. MDOT divides its network of connecting segments into nonmotorized, rail, road and water systems. Due to mileage, highways receive much of the attention. However, each system allows users to establish and store routes/corridors for analysis. Each is also able to geographically display results of an analysis. When integration is complete in February, 1998, users will be able to establish routes across modes; effectively making the transportation system an homogenous unit.

The points at which people and goods are exchanged between systems, or between different parts of a system, are facilities. These include airports, border crossings, carpool parking lots, intercity bus and rail stations, pipeline terminals, ports, container/trailer terminals, rail freight stations and weigh stations. The balance here gives each equal treatment in the management of physical inventory, usage, trend and image data. Also, any user has access to the supplemental comment function; a free form text utility which is MDOT's corporate conscience.

The proper balance does not always mean a decision near the middle of the spectrum. Highway decisions made without knowledge of nonhighway alternatives may be less than optimal. Thus for IMS, the proper balance in data accessibility is for all personnel to have access to all data. The common bond is location, and all facilities and systems can be balanced with each other based on this link.

Another balance not made by splitting the difference was that of scheduled passenger services. Though MDOT does not track freight service provision, the supply of intercity air, bus, marine and rail passenger services are tracked and compared across modes through IMS. Where appropriate, information on subsidy/guarantee, equipment loans and ridership can be managed and displayed.

The balance most important to IMS is between support for strategic and tactical decisions. The ability to assess a project's ability to meet long term goals, is balanced against the day to day tasks of personnel who manage such projects. To assure user acceptance of the tool as the means of performing their tasks, an easy to use interface, which structures and eases many of the time consuming data management functions, is provided by IMS. Now structured modal specialists, with no additional work on their part, also provide data necessary to answering strategic questions. This is done through performance measures; indicators of facility performance compared against standards or benchmarks.

Using actual output from the system, this paper will discuss balances struck in the development, user acceptance and operation of IMS. It will include discussion of the impacts of database design, common interfaces, data accessibility, training, performance measures and geographic indexing on the ability of personnel to use the tool in their tactical decision making, while still assuring that managers have the ability to take a step back from such decisions to make strategic assessments.

Prior to passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the Michigan Department of Transportation (MDOT) used mode specific tools defined by appropriate federal or state agencies to support intermodal decision making. ISTEA mandates, later relegated to recommendations, provided the impetus to find a means by which these varied methods could be, if not standardized, made common enough to allow comparison of the needs of one mode with those of another. The Intermodal Management System (IMS) was developed to allow planners, engineers, analysts and managers to balance issues required to efficiently make effective decisions, leading to seamless connections for nonmotorized, rail, road and waterborne people and goods.

MDOT assigned a very high priority to development of the Transportation Management System (TMS), of which IMS is a part. And though the state placed a very strong emphasis on automation of processes, this was not the main or only purpose of the effort. Early in the development process, it became apparent that issues of database design, data accessibility, commonality, training and user acceptance, performance measures and geographic indexing had to be addressed in more than a cursory manner. Perhaps most traumatic for MDOT, even the way we made modal decisions had to be questioned.

Automation & Integrated Decisions

When Congress passed the ISTEA legislation, it was made clear that each state was to improve or develop their planning process to integrate all aspects of transportation planning. Unfortunately, the very breadth of the issues requiring integration, was partially responsible for segregation. Bridge, congestion, intermodal, pavement, public transit and safety issues are generally handled by specialists in each field. And these people rarely have the time to consider the perspective of people in other disciplines, let alone the fiscal ramifications of their actions.

Politics aside, this segregation is more often because each group lacks *quick* access to the *frame of reference* in which the others work. This occurs despite the fact that each cell of workers is using essentially the same means of arriving at a decision (i.e., Set goal, collect data, analyze data, produce solution, check results against goal). Most organizational or paper based schemes can provide the means to integrate the various *frames of reference*. However, only an automated structure can provide the *quick* response required to make integration truly feasible. For this reason, MDOT developed an *automated* TMS.

However, an automated TMS does <u>not</u> assure integrated decision making. TMS is a *toolbox*, with several *tools* used to *support* integrated decision making. IMS is but one of these tools, each of which provides all transportation professionals with the timely ability to view their work from the perspective of others. This distinction between the planning process and the support provided by the automated functions, or tools, is important. To reinforce this difference in the minds of users, the department's bimonthly TMS newsletter is even referred to as *TMS Toolbox*.

Balance vs. Compromise

A *compromise* is defined as, "A settlement of differences in which each side makes concessions or a concession to something that is detrimental or pejorative."[1] Under this definition, one side of an issue is sacrificed to benefit the other, or a negative impact to one side of an issue accrues in obtaining the accepted result. Given the nature of modal planning, which may include comparisons of publicly and privately owned infrastructure, this means of resolving development issues was not considered acceptable.

Alternatively, a *balance* is defined as, “An harmonious or satisfying arrangement or proportion of parts or elements.”[2] This is the way in which MDOT met the development challenge of IMS. In striking *balances* between various issues, one aspect of an issue was optimized to the point at which any further improvement would create a negative feature in other aspects. In this way, the department avoided creating situations in which some aspect of an issue was sacrificed to benefit another. This, in turn, led to the combining of the best facets of the various modal methods into a consistent and usable management system.

Given MDOT’s organization of personnel, which utilizes experienced specialists for each mode of transportation, it must be admitted that this did not always work smoothly. It is not uncommon for people to resist change. However, our experience was that when a balance proved difficult to achieve, the process tended to force scrutiny of the perceived negative aspect. Often, those most resistant to change found a superior way of doing what was under consideration. And since in many cases that way was to make it easier, or not to do it at all, balance was achieved with a minimum of friction.

System Integration: Full vs. None

In an intermodal decision support tool, the first *balance* required was that between modal systems. Systems are the transportation connections by which people and/or goods are moved between points. For purposes of administration, MDOT divides its overall transportation network into nonmotorized, rail, road and water (marine ferry) systems. Each of these networks is defined as a set of distinct segments. Analyses are performed on *routes*; user defined groups of segments selected to connect two pertinent points.

Due to the preponderance of mileage, highways received much of MDOT’s attention. In fact, the Bridge, Pavement and Safety portions of the department’s TMS are tools devoted almost exclusively to decision support required to maintain the state’s roadways. Additionally, the Congestion part of TMS is concerned with the mobility of Michigan’s citizens, visitors and commercial interests over the highway system. However, to support analysis of movements of passengers and goods, IMS was designed to manage the assets that constitute the nonmotorized, rail and waterway systems.

In this regard, IMS balanced the unique natures of each mode against the desire and need to treat our transportation network as an integrated whole. The result was the adaptation of the same linear reference model used for our highway system, to the other systems. This model is a commonly used method in which each piece of the network is assigned a unique identifier. At MDOT this is known as a *Physical Reference* (PR) number. The segment is further described by a beginning and ending milepoint. Thus any data attribute can be ascribed to a segment by denoting the PR number and milepoint (for point specific data), or beginning and ending milepoints (for data over a length). The example of the number of mainline tracks maintained by Canadian National Railways in Clinton, Eaton and Ingham Counties (commonly called the Tri-County area) is shown in Exhibit 1.

Each data attribute is stored in a separate table of the database. Thus, as shown in Exhibit 2, the data for freight train frequency is stored in a table separate from that for number of tracks.Only when the user defines a route for study, and selects the data attributes required for analysis, does the application select those elements and construct a unique study segment through a process known as *Dynamic Segmentation*.

For example, the previously mentioned Tri-County area is served by the Chicago Subdivision of Canadian National Railways. In the study area, this line is designated *PR* segment 7308900. To analyze rail issues related to the number of mainline tracks and the frequency of freight train movements, TMS/IMS creates the study segment shown in Exhibit 3.

Within this study segment (sometimes referred to as a detail or break report), the Lansing/East Lansing Amtrak Station (a point) is located at milepoint 223.900 on PR number 7308900. From the information shown, we know that at this station, the line is double tracked and handles approximately 28 trains per day. Similar analysis can be performed over any length or at any point of the route.

Exhibit 1: Number of mainline tracks on Canadian National rail lines in the Tri-County area

PR Nbr.	Beg. MP	End MP	Subdivision	Nbr. of Tracks
7308900	188.451	214.800	CN-Chicago	2
7308900	214.800	221.500	CN-Chicago	1
7308900	221.500	232.699	CN-Chicago	2

Exhibit 2: Freight train frequency on Canadian National rail lines in the Tri-County area

PR Nbr.	Beg. MP	End MP	Subdivision	Frgt. Freq.
7308900	188.451	201.995	CN-Chicago	30
7308900	201.995	202.140	CN-Chicago	24
7308900	202.140	202.385	CN-Chicago	30
7308900	202.385	202.975	CN-Chicago	24
7308900	202.975	217.880	CN-Chicago	30
7308900	217.880	225.220	CN-Chicago	28
7308900	225.220	228.260	CN-Chicago	24
7308900	228.260	232.699	CN-Chicago	28

The application allows users of each modal system to establish and store routes/corridors for analysis. Each will also be able to graphically display results of an analysis. However, MDOT was forced to balance the ability to fully integrate across all modes, with the ability to develop and release our tools in a timely manner. For though the rail referencing system is complete (though not fully supported by data) and the waterway system requires little data of its own, the road system currently includes only National Highway System (NHS) and state trunkline routes, and the nonmotorized system is being constructed as projects are undertaken. Thus, the balance achieved was to fully utilize the highway reference example, but *temporarily* maintain the modes separately. When referencing of the roadway system is complete (February, 1998), full integration of the separate modal networks will begin. For planning and decision making purposes, this will effectively make the transportation system an homogenous unit.

Exhibit 3: Dynamic segmentation of Canadian National rail lines in the Tri-County area

PR Nbr.	Beg. MP	End MP	Subdivision	Nbr. Tracks	Frgt. Freq.
7308900	188.451	201.995	CN-Chicago	2	30
7308900	201.995	202.140	CN-Chicago	2	24
7308900	202.140	202.385	CN-Chicago	2	30
7308900	202.385	202.975	CN-Chicago	2	24
7308900	202.975	214.880	CN-Chicago	2	30
7308900	214.880	217.880	CN-Chicago	1	30
7308900	217.880	221.500	CN-Chicago	1	28
7308900	221.500	225.220	CN-Chicago	2	28
7308900	225.220	228.260	CN-Chicago	2	24
7308900	228.260	232.699	CN-Chicago	2	28

The impact of this balance of various

issues was generally positive:

Database Design: This type of linear reference model is perfectly suited to the construction of a fully normalized, relational database. As each data attribute can be stored in a separate table, updates to one attribute do not require resegmentation of the entire database. Also, the addition of attributes at a later date can be done with minimal or no disruption to existing elements.

Data Accessibility: Data security can be part of the database, as well as any application interface. This allows the database to be used by any user on a read only basis, even if they lack access via TMS. In turn, this allows MDOT to leverage the cost of data gathering for management tools across other applications.

Training: Relational databases are often difficult for novice users to understand. However, by leveraging data collection over the entire organization, the need to train large numbers of personnel in its use can be mitigated by designing custom applications for commonly performed functions.

Commonality: The use of the commonly accepted linear reference methodology will ease the transition from separate modal systems to a comprehensive, multimodal transportation network.

Geographic Indexing: Similarly, the shift from a linear reference method of system inventory to a map coordinate based method will be relatively simple. Efforts with other departments of Michigan government are underway to assure that as many different types of geographically referenceable data as possible are being commonly indexed. This will allow the state to leverage the costs of the next, logical steps across large numbers of functions.

Performance Measures: Each mode exists to serve a different part of the transportation market. Thus, a comparison of the speed of a truck on the highway network to the ability to move large tonnages by rail currently has little or no meaning. However, consistently managed data may eventually allow modal network comparisons of *customer* utility.

Tactical Decision Making: All data collected on each modal system (except that which the department is legally prohibited from disseminating), is available to any user who requires access. Assuring all users timely access to data which may impact their workflow, minimizes the possibility of decisions being made without due consideration of all factors, regardless of mode.

Strategic Assessments: Management of data on all modal systems in a consistent manner will allow easier comparisons of benefits and costs across all modes. With eventual full integration, decisions on policy and spending could be made irrespective of mode.

Facilities: Inclusive vs. Exclusive

The points at which people and goods are exchanged between systems, or between different parts of a system, are facilities. In Michigan, these include airports, border crossings, carpool parking lots, intercity bus and rail stations (henceforth referred to as intermodal passenger facilities), pipeline terminals, ports, container/trailer terminals, rail freight stations and weigh stations.

In this instance, a decision as to what facilities would be monitored by IMS was required. One choice was an exclusive model; in which facilities would be included only if they meet a predetermined standard of mode, data access, activity level, importance to the jurisdiction served and/or governmental ability to influence. The alternative was an inclusive model; in which all facilities were included, regardless of how they fit into the transportation system. The balances struck proved fairly simple.

With regards to mode, all of the aforementioned types of facilities were included. Originally, this was due to ISTEA mandates. However, even when these requirements were removed, the functions of the department made it clear that failure to include any of these components would be detrimental to the overall decision making process.

In terms of activity levels and importance to jurisdictions served, it was not deemed feasible or appropriate for MDOT to set a threshold level for inclusion in a management tool which would be shared with other governmental agencies. Also, to assure inclusion of all facilities that met such strictures, it was determined that all facilities would need to be monitored anyway.

Thus, the balance the department wanted to achieve was the inclusion of *all* facilities. However, the ability of the government to influence, or even gain access to data about certain facilities, did result in an inability to include some facilities in the inventory. Due to their negligible impact on other modes, or the communities they served, privately owned and used airports (i.e.: not open to the public), were not included.

A second balance struck on this issue was the level of information to be kept about each facility. The *balance* here requires a certain minimum level of physical inventory and modal access data from each facility. IMS then incorporated mode specific functions which reflected the levels of physical inventory, usage, trend and image data already monitored by the department. Thus, the impact of this decision was minimal to most facility types. Those facilities which were required or had chosen to maintain more detailed data, such as airports, continued to do so. Those modes for which minimal data was available, such as pipeline terminals, met the established minimums and went no further. In short, IMS reflected organizational functions. It did not impose an inappropriate or unattainable standard of data maintenance.

One function which IMS does provide for all modal facilities, and which all authorized users can access, is *Supplemental Comment*. This is a free form text utility which links and organizes non-quantifiable data to the facility to which it is related. Any user can use the utility to store everything from quick notes to summaries of completed reports.

Several facility types have chosen to use supplemental comment for more structured purposes. Planners working with the state's carpool parking lots use the function to store citizen survey comments from periodic polls. Planners dealing with airports use it to store explanations of Federal Aviation Administration and MDOT classification schemes, as well as data collection methodologies. Regardless, as this function is used, it will become the transportation memory for the state and our partners in planning and development.

The degree of commonality and improved access to the data provide one immediate benefit to planners, engineers and analysts; the ability to say *no*. Often, governmental agencies receive requests for infrastructure, or studies leading to projects that are not in their interest to pursue. Until now, even a cursory analysis to determine the feasibility of continued study was, in and of itself, a time consuming study. Much of this time was spent gathering data to document why the project was not worthwhile.

With TMS/IMS, modal data can be quickly integrated, analyzed and presented to the party making the request. If the project makes sense, it can be passed on for further work. If the project is marginal, the requesting agency has an idea of what is necessary for resubmission. If the project is not worthwhile, MDOT or our governmental partners can give a definitive, well documented negative answer.

This capability is in keeping with MDOT's desire to empower the lowest appropriate level of management with decision making authority. By documenting their decision with readily available data, the professional eliminates one source of citizen/customer complaint; the lack of a timely and definitive answer.

The impact of this balance of various issues was generally positive:

Database Design: The database reflects the department's current and expected needs. Those modes required to maintain more detailed data, continue to do so. Thus, the database design and subsequent data loading, can reflect relationships already understood by modal specialists, if not by most users.

Commonality: When accessing information on facilities, the user is no longer required to search for airports in one application, and ports in another. Now they search for *Intermodal Facilities* and receive data on all pertinent sites, regardless of mode. While IMS allows an analysis to treat all facilities as common entities, the application does not lose the unique nature of individual modes.

Data Accessibility: Meeting the established minimum level of physical inventory and modal access data assures that transportation professionals are able to ascertain what facilities might be impacted by their work.

Training: It is hoped that supplemental comment will help to minimize the impacts that changes of personnel have upon programs with small staffs.

Performance Measures: The ability to treat all intermodal facilities in a similar manner allows augmentation of mode specific performance measures with development of measure common to all facility types. By developing common, access related measures, the effectiveness of projects on the transportation system as a whole can be considered without regard to the mode involved.

Geographic Indexing: By tagging all intermodal facilities with their location, analyses on corridors and other geographic areas can include all transportation assets with little or no additional effort.

Tactical Decision Making: The ability to quickly access, display and forward basic information on transportation infrastructure is a benefit to modal specialists. It is unknown if the ability of all users to access this same information will increase or decrease the workload of specialists. If users find the data adequately answers their query, a decrease should occur. If it does not, or users did not previously understand the importance of intermodal facilities, a temporary increase in questions caused by a sort of *learning curve* will occur. Either way, an overall improvement in the quality of tactical decisions should occur.

Strategic Assessments: The ability to provide information in a format that allows quick overview by programming/funding and policy personnel will improve not only the speed of strategic decision making but, as all modal issues are now easily blended, the quality of those decisions. In addition, the ability to prevent less consequential decisions from being elevated to higher levels of authority, allows management to concentrate on cohesive programming and policy decisions, not on minutia.

Services: Necessity vs. Extra

Another *balance* struck was in the area of *services*. Services are scheduled or regular intercity movements of people and/or goods, along a system, between facilities and/or their points of origin. In some instances, MDOT was also responsible for information on subsidy/guarantee, equipment loans and ridership. Once again, the choice was whether to include or exclude the management and display of various service information.

Analysis of benefits to be derived from direct tracking of freight services indicated that, even if possible, the cost would be prohibitively high. Conversely, the periodic tracking of scheduled passenger services could be performed with readily available, inexpensive to maintain data. Thus, MDOT struck a balance by not directly tracking provision of freight services. However, the supply of scheduled intercity air, bus, marine and rail passenger services are tracked and compared across modes through IMS.

The inclusion of services in IMS was the result of history and need. Historically, MDOT has maintained data on both the demand for intercity passenger services (dis/embarking passengers) and the supply provided by serving carriers (arrivals/departures). This was needed to justify state expenditures on air carrier airport development, air service guarantees, intercity bus subsidies/ equipment loans, and *Section 403b* state subsidized intercity rail services. However, the decisions made based on this data were specific to the individual mode of transportation.

To promote provision of seamlessly integrated intercity passenger services required a change in thinking. The balance struck was to change our focus from *what cities can a mode serve*, to *which service(s) provide the best customer service or utility to a community*? MDOT's tracking of services provided gave the necessary method of comparing services across modes: *weekly arrivals/ departures*[3]. Eventually, comparing this to passenger demand experienced at various levels of supply in demographically defined areas (peer groups), will allow utility thresholds to be established.

With properly developed utility measures in place, MDOT can work with providers of scheduled passenger services to achieve a service provision balance that meets the needs of a community on a cost effective basis. Where that service balance cannot be achieved, the documentation of why service support is not feasible can be used to prevent expenditure of funds due to political pressure.

The impact of this balance of various issues was generally positive:

Database Design: While the use of periodic sample data from published sources does not allow direct measurement of certain aspects of service provision, it does allow analysis of trends and establishment of utility measures in demographic peer groups at a reasonable cost. More importantly, this can be done across modes and without the problems inherent in asking deregulated, private sector companies to submit data they may consider proprietary.

Commonality: The use of the weekly arrivals/ departures measure allows service comparisons across modes.

Data Accessibility: As the data is not proprietary in nature, private sector service providers can/will not block dissemination to TMS users. Additionally, weekly arrivals/departures are fairly logical and well understood measures of importance amongst transportation professionals and public officials.

Performance Measures: It is not in the state's interest to attempt to *enforce* a level of service on private sector carriers. However, the use of service utility measures to justify state support of air, bus or rail services in a community makes sense and could help remove this decision from the political arena.

Geographic Indexing: The location of services along the proper segments allows analysis of services to communities using all data in TMS/IMS. No additional work is necessary from transportation professionals.

Tactical Decision Making: The ability to quickly access, display and forward basic information on transportation services is a benefit to modal specialists and other users. However, most decisions regarding services are strategic in nature.

Strategic Assessments: Prior to IMS, development and management of a balanced air/bus/rail passenger strategy has been difficult. The drawing together of data and standardization of comparative measures will allow a shift in thinking from where is the service, to where should we have service. Expenditures of state funds to support services by federal (Amtrak) or private entities (airlines, bus lines) need to serve the greatest numbers of people possible for each dollar, while supporting Michigan's goals of assuring its residents, visitors and commercial interests have appropriate choices in intercity passenger transportation.

Data Access: No One vs. Everyone

As seen in the preceding sections, the proper *balance* does not always mean a decision near the middle of the spectrum. Nowhere is this more true than in the issue of data access. Highway decisions made without knowledge of nonhighway issues or alternatives will almost certainly be less than optimal. And as we are aiming for optimal *transportation* solutions, the proper balance of data accessibility is for *all* personnel to have access to *all* data.

Of course, there are restrictions to what *all* data encompasses. Aside from MDOT's short term inability to integrate data from every legacy application into TMS, what is accessible through our tool is limited by existing legal restrictions related to privacy and/or collection of proprietary information. To allow access to data under existing legal restrictions, it is aggregated in a way which does not allow a user to see privileged information, yet still allows its use in planning and decision making. In the example of air carrier activity statistics, the reports of the individual airlines are amalgamated to the airport level prior to display in IMS. In the case of legacy applications, some data access is provided through use of *Object Link Embedding* (OLE).

To prevent data overload, a user requires a commonly understood relationship of information to know which data to access. The simplest of these, and the one chosen by TMS, is location. All facilities and systems (and eventually services), can be *balanced* with each other based on this link. Currently, this link is based on the PR numbers and milepoints used to define our modal networks. In the future, this will probably move to a simpler *latitude/longitude* coordinate model. Either way, the decision maker can now access any or all data, regardless of mode, for a specified study area.

The impact of this balance of various issues was generally positive:

Database Design: Minimizing restrictions in data access minimizes the security chores of database managers and programmer/developers. In addition, it allows unrestricted use of the supporting database, even if the user does not have access through the TMS/IMS interface.

Commonality: A TMS user who accesses IMS most often and is familiar with the way in which the data is used, will find the same patterns in data managed in other areas of responsibility.

Data Accessibility: Users access is restricted only by existing legal constraints.

Training: Users need only learn one part of TMS to understand the way in which data is accessed in all parts of the application.

Performance Measures: Not only is data readily available to all users, the measures used to justify projects and measure success are also documented and available for reference or use.

Tactical Decision Making: Planners, engineers and analysts have access to the same data as their managers.

Strategic Assessments: Without additional burdens on planners, engineers and analysts, managers have access to all of the data, not just that for which they are responsible.

Interface: Common vs. Specialized

The way in which the ISTEA legislation was written led many transportation professionals, including many at MDOT, to believe that individual applications relating to Bridge, Congestion, Intermodal, Pavement, Public Transit and Safety should be developed independent of each other. In Michigan, the state/metropolitan planning agency planning processes were already so integrated that six separate applications would not have effectively supported what existed, let alone the improvements ISTEA envisioned. As such, separate development was never seriously considered.

For similar reasons of decision support, MDOT also chose to develop a common interface for all six sections of an integrated TMS. This was deemed necessary in order to maximize the ability of all users to access pertinent information.

It should be noted that a *common* interface is not the same as an *identical* interface. In MDOT's common TMS interface, elements of any given display function the same in IMS, or any of the other five parts of the application. Standard features such as pull down menus, text fields and indicator boxes operate in a manner which most *Windows* computer users consider *normal*. In addition, tabular displays and organizational tools operate the same across all sections of TMS. However, as the data shown in IMS will be different from that displayed in other parts of the tool, the actual screen displays will also differ. Nonetheless, the behavior of elements in each part of the overall application are the same.

The impact of this balance of various issues was generally positive:

Database Design: The design of the user interface should never drive the design of the relational database it accesses. That type of *applicational* database design limits future flexibility.

Commonality: A user trained to use IMS will have little difficulty operating another part of TMS. The MDOT training regime starts with basic navigation which teaches the concept of using common parts of the interface. This saves time in teaching the six parts of the overall TMS.

Training: A user trained to use IMS will have little difficulty operating another part of TMS.

Tactical/Strategic Assessments: Users familiar with analytical tools used to support tactical or strategic decisions, can easily use those designed to support the other type of decision.

Decisions: Strategic vs. Tactical

The *balance* most important to IMS is between support for strategic and tactical decisions. The ability to assess a how a project meets long term goals, is *balanced* against the day to day tasks of personnel who manage such projects. As the data necessary for decision making at any level consists of the same basic variables, the balance struck by TMS/IMS was to standardize basic analytical tools required to turn raw data into information usable at all levels of the organization. This allows MDOT to meet both the needs of management and their subordinates.

However, to assure this would work, IMS needed to assure user acceptance of the tool as the means of performing their tasks. To do this, an easy to use interface was developed which structures and eases many time consuming data management functions. Using these interfaces, modal specialists enter the data only once. IMS then places it in the appropriate areas of the relational database, ready for use by standard analytical tools.

Those analytical tools can range from the simplest data display to complicated analyses of facility access. However, the key is that, with no additional work on their part, the person responsible for the provision and quality of necessary data, has made their work available in an appropriate format to all levels of MDOT, as well as to its federal and local partners.

At the tactical end of the spectrum, IMS is used to answer the most commonly asked questions received by planners, engineers and analysts. These include those related to the physical inventory and usage of Michigan's intermodal facilities. Users can access current and historical data on all modes, filter out what is not pertinent to their request/analysis, and display the results in tabular or graphic form. Most data can also be exported to various specialty software packages for further analysis. To give a context to the information they are seeing, users also have access to any maps, sketches, photographs (known collectively as *Images*) or notes and comments (*Supplemental Comment*) linked to the facility by modal specialists.

As any user can access this information, in the long run the time savings this will create for modal specialists will probably never be fully measurable. However, as IMS is used by greater numbers of people, there may be a period of time during which users have questions on what they are accessing. As such, during this learning curve, additional efforts may be required.

Planners, engineers and analysts also use IMS to ascertain deficiencies and define needs. The analytical tools used are performance measures. It is important to discern the distinction between performance *measures* and *indicators*. Both measure the same aspect of the transportation infrastructure. However, indicators lack standards against which effectiveness can be judged. It is these identifiable and measurable levels of achievement, surveyed over time, that allow IMS users to evaluate deficiencies in the flows of people and goods.

IMS performance measures are currently far from being absolute rules. Until such time as modal systems plans and experience allow federal, state and local organizations to jointly establish appropriate standards, they are used as planning aids. An IMS defined deficiency is not a reason to dispatch a construction crew. It is a reminder to the planners, engineers and analysts to look more closely at what might be a problem. Conversely, it is understood that transportation professionals will need to identify deficiencies not caught by the application. Even when standards are established for IMS performance measures, they will not be static values. Instead, they will reflect the best current assessment of deficiency in *general* situations.

Solutions to these deficiencies are documented by planners, engineers and analysts in a standard tool known as the *Transportation Analysis Notebook* (TAN). The TAN is the link between the project oriented tactical work of transportation professionals, and the program/budget work of department management. From the documentation provided by a TAN, managers and budget personnel are able to *package* various individual projects into logical groupings for the letting of bids. More importantly, MDOT personnel are able to do this regardless of mode or funding source.

This does not mean the abolition of discrete monies for specific modes (though that could eventually happen). It does, however, mean that overhead costs associated with construction and maintenance of transportation systems and facilities, can be leveraged over a wider retirement of needs. This will result in more high quality infrastructure for the dollar. And after a period of reshaping the traditional single-mode thinking of management, this should also lead to planning for smoother connections between modes.

The same performance measures that allow planners, engineers and analysts to identify deficiencies, allow management (and any other user so inclined) to quantify the effectiveness of chosen strategies in meeting those defined needs. Traditionally this required additional staff time to reanalyze, or at least reformat, the required data. By agreeing to standards of performance, IMS is able to provide the necessary analysis, in the required format for all levels of user. Still, there is no additional workload placed upon staff.

The impact of this balance of various issues was generally positive:

Database Design: Defined relationships must take into account the processes by which decisions are made. However, these relationships must reflect, not define the organization.

Commonality: Commonality between the tools used by planner, engineers and analysts to define needs, and those used by managers to assess priorities and define groups of projects need not be the same. A common interface has benefits in the training of personnel for advancement, or allows easier checking of a subordinate’s work.

Data Accessibility: All levels of the organization access the same data. Only the application developed to turn that data into useful information needs to change.

Performance Measures: The use of similar and/or identical performance measures to define needs and assess success in meeting those needs has several advantages. These include fewer points of required agreement amongst agencies and overall acceptance of goals by the whole organization.

Tactical/Strategic Decision Making: In TMS/ IMS, the only difference between these types of decisions is the developed analytical tool. As many of these will be the same, much of the cost of this effort can be leveraged over multiple functions. However, the data remains the same.

Technical Support: Full vs. None

There was a time when federal requirements for an automated TMS were dropped, that MDOT considered returning to a less integrated, computer based scheme. The political climate of downsizing in the state aside, MDOT and our governmental partners chose to improve the quality of decision making by integrating as much information as possible. This required much improved access by those responsible for the planning process. And that, in turn, required us to continue development of an automated TMS/IMS.

As such, MDOT found that in the area of technical support, only one possible balance can be struck: Technical support must receive the highest possible management commitment if an automated and integrated TMS/IMS is to work. This does not only mean the purchase of the computers and communications equipment required to run the applications. That is the easiest part. It also includes the trained personnel required to support the hard/software needed to keep users from being idled, and the training necessary to allow them to use the application to its fullest potential.

Conclusions

The process of developing MDOT's automated TMS application was a difficult balancing act. In particular, the balancing of intermodal issues to produce a cohesive intermodal decision support tool posed many problems not previously addressed by the department. Nonetheless, without introducing negative changes into any one mode, MDOT was able to produce an IMS which allows all users full access to data on modal facilities, systems and services which affect their work. This was achieved by striking a balances in each of the following areas:

<u>Systems</u>: The optimal solution, and that which MDOT hopes to implement in 1998, is to fully integrate the nonmotorized, rail, road and waterway networks under a single linear reference model. However, the department was forced to balance the desire to fully integrate across all modes, with the ability to develop and release our tools in a timely manner. The balance achieved was to fully utilize the highway reference example, but *temporarily* maintain the modes separately. When referencing of the roadway system is complete (February, 1998), full integration of the separate modal networks will begin. For planning and decision making purposes, this will effectively make the transportation system an homogenous unit.

<u>Facilities</u>: Even without ISTEA requirements, Michigan chose to include airports, border crossings, carpool parking lots, intermodal passenger facilities, pipeline terminals, ports, container/trailer terminals, rail freight stations and weigh stations in the IMS. The functions of the department made it clear that failure to include any of these components would be detrimental to the overall decision making process. As it was not deemed feasible or appropriate for MDOT alone to set a threshold level for inclusion, and as such a threshold would still require monitoring of the facility, all facilities except privately owned and used airports were included. Each facility type is required to maintain a minimum level of physical inventory and modal access data. Beyond that, each mode maintains the level of data appropriate to its needs.

<u>Services</u>: Due to the high cost of tracking the provision of freight services, MDOT struck a balance by monitoring only the supply of scheduled intercity air, bus, marine and rail passenger services. Data on passenger services was needed to justify state expenditures on guarantee, subsidy and equipment loan programs. To promote provision of seamlessly integrated intercity passenger

services required the department to change our focus from *what cities can a mode serve*, to *which service(s) provide the best customer service or utility to a community*? With properly developed utility measures in place, MDOT can work with providers of scheduled passenger services to achieve a service provision balance that meets the needs of a community on a cost effective basis. Where that service balance cannot be achieved, the documentation of why service support is not feasible can be used to prevent expenditure of funds due to political pressure.

Data Access: As we are aiming for optimal *transportation* solutions, the proper balance of data accessibility is for *all* personnel to have access to *all* data. In the long term, what is accessible through our tool is limited only by legal restrictions related to privacy and/or collection of proprietary information. To allow access to data under existing legal restrictions, it is aggregated in a way which does not allow a user to see privileged information, yet still allows its use in planning and decision making.

Interface: As TMS is intended to be an integrated decision support tool, MDOT chose to develop a common interface for all six sections of its integrated TMS. This was necessary to maximize the ability of all users to access pertinent information. Standard features, such as pull down menus, text fields and indicator boxes, operate in a manner which most *Windows* computer users consider *normal*. However, as the data shown in IMS will be different from that displayed in other parts of the tool, the actual screen displays will also differ. Nonetheless, the behavior of elements in each part of the overall application are the same.

Decisions: The *balance* most important to IMS is between support for strategic and tactical decisions. The ability to assess a how a project meets long term goals, is *balanced* against the day to day tasks of personnel who manage such projects. As the data necessary for decision making at any level consists of the same basic variables, the balance struck by TMS/IMS was to standardize basic analytical tools required to turn raw data into information usable at all levels of the organization. This allows MDOT to meet both the needs of management and their subordinates. Nonetheless, to assure this works requires: user acceptance of the tool as the means of performing their tasks, professional confidence in the person(s) responsible for the provision and quality of necessary data, flexibility in the application of performance standards, an understanding that performance measures reflect the best current assessment of deficiency in *general* situations, and the ability of management to access information required to monitor the quality of their actions with no additional workload placed upon their staff.

Technical Support: Technical support must receive the highest possible management commitment if an automated and integrated TMS/IMS is to work. This must include more than the purchase of the computers and communications equipment required to run the applications. It requires commitment to the trained personnel necessary to support the hard/software needed to keep users from being idled, and the training necessary to allow them to use the application to its fullest potential.

Notes

1. American Heritage Dictionary (The); 2nd Ed., Houghton Mifflin Company, 1976
2. Ibid.
3. In theory, a community will have an arrival for each departure. However, as only scheduled

services, not nonrevenue movements, are measured, it is possible for these numbers to differ; particularly with air service. Given the minimal number of services where this was a problem, MDOT chose to assume that arrivals and departures were always equal.

For Additional Information

If you have any questions or need additional information on the way in which MDOT has developed and/or instituted its IMS, feel free to contact:

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Evaluating Traffic Impact Studies, A Recommended Practice for Michigan Communities

Bradley K. Strader, McKenna Associates; Pete La Mourie, Progressive Engineering;
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Abstract

Communities and road agencies in Michigan are continually confronted with proposals for new development. Traffic impacts are often a major concern of both the community and the road agency. The lack of an accepted practice for when traffic impact studies should be submitted, and what evaluation should be included led to inconsistent studies and varying requirements throughout Michigan. In addition, there is growing litigation regarding the responsibility of developers to correct deficiencies in the transportation system. Transportation professionals, developers, attorneys and public officials agreed that a standard practice for Michigan was needed.

In response to this dilemma, the handbook *Evaluating Traffic Impact Studies, A Recommended Practice for Michigan Communities* was developed. This handbook was reviewed by the committee of 70 transportation professions, developers, public officials and attorneys. The handbook builds upon previous work in Michigan, ITE and other states, but also addresses or links new topics. This handbook describes:

- Benefits of traffic impact
- When traffic impact studies should be
- The level of analysis needed for different situations or land uses
- Recommendations on trip generation rates, pass-by-rates, background traffic volumes, evaluation of mitigation alternatives and other issues involved in the preparation of traffic impact studies
- Elements beyond “traditional” traffic impact studies that should be included, such as access management alternatives
- Qualifications for the preparer and reviewer
- How community and road agency staff should coordinate their development reviews

The benefit of an agreed upon practice in Michigan could be realized by other states, MPO’s, communities or agencies. The handbook has become recognized as the standard practice in Michigan. Numerous communities have adopted the handbook through their zoning ordinance. Many road agencies now reference the handbook when reviewing development proposals. Most preparers of traffic impact studies, and an increasing number of reviewers, use the handbook. Copies were distributed to communities and road agencies throughout Michigan. A slide presentation on the handbook was prepared an has been presented throughout Michigan. A slide presentation on the handbook was prepared and has been presented throughout Michigan. The handbook generated interest from the Michigan Society of Planning Officials, which used the handbook as the foundation for a four-hour instructional program, “Managing Traffic in Your Community”, which continues to be presented throughout Michigan.

Coordinating Land Use and Transportation Through Access Management

Kristine M. Williams, University of South Florida

Abstract

A central challenge of contemporary transportation planning is determining how to better coordinate transportation and land use plan and practices. The challenge of implementing transportation plans lies in the dynamic interaction between transportation and land use. The land use plan used to predict transportation needs inevitably changes as new highways stimulate real estate speculation, rezoning, and growth. New development may foreclose opportunities to expand or interconnect roads, where needed. Thoroughfare frontage may be subdivided into small lots, increasing demand for direct highway access. Highway frontage may be strip zoned for commercial development, with little attention to access control. Poorly coordinated access systems force more trips onto the arterial, traffic conflicts multiply, and congestion increases. Road improvements are needed sooner than expected and the cycle begins again.

Transportation and land use problems are interdependent and require coordinated solutions. This session would explore typical problems in land use planning and regulation that adversely attack the transportation network, and how access management techniques can be applied to improve coordination and consistency of land use and transportation decisions.

Urban Design, Urban Form, And Employee Travel Behavior

G. Bruce Douglas, III and John E. (Jay) Evans, IV,
Parsons Brinckerhoff Quade & Douglas, Inc.

Abstract

Personal travel behavior choices made by employees appear to be influenced by a number of urban design and urban form characteristics of their work place. Several important attributes include the density of development and the accessibility of non-work activities, such as eating at restaurants and shopping (frequently accompanied by a greater mix of land uses).

The research reported in this study focuses on travel choices made by employees during their commute to work and during their work day. Travel patterns were examined for employees in four different urban and suburban employment centers. The mix of uses varied from a virtual single use center to a full urban core with numerous types of activities. Walk accessibility to the various activity centers (or buildings) varied from site to site. The various sites also contain different levels of transit service.

Travel patterns recorded in a one-day diary format included the journey to work, trips made from the office to other non-work and work locations during the day, and the journey from work to home, including additional stops. These patterns resulted in trip chains of different lengths and different temporal distributions.

The research revealed strong relations between the various urban form/urban design characteristics and the total number of trips made per day, the total number of trips by individual modes (transit, walking, automobile), and the number of trips made by trip purpose. Differences in the number of auto starts and vehicle miles of travel were calculated. The data suggest dramatic differences in the travel patterns of employees with similar jobs and incomes depending on the urban character of the work place (including mix of land uses.)

An additional insight derived from the analysis was the difficulty in isolating the causal relationships between trip making and mode choice in relation to urban design, urban form and transit service variables. In many cases, the different characteristics of the travel experience occur in a synergistic format. For example, increased density, increased mix of uses, and high level transit service are all available at a single site. Another site may have a very low mix of uses, poor pedestrian accessibility and poor transit service, leading to either extremely high automobile use or reduced overall trip making.

As part of two transportation studies, a total of four employee travel surveys were developed and administered in employment centers located along Metrorail’s Red Line between Downtown Washington, D.C., and the Shady Grove area in Maryland. Each of these areas has different urban form and urban design characteristics. The surveys were designed to determine differences in employee travel behavior among the areas. Among the survey objectives were to determine mode choice pattern for commuter trips and to investigate travel behavior during the work day.

Areas Surveyed

The four areas surveyed were the downtown CBD (Washington, D.C.), a suburban CBD (Bethesda, Md.), a suburban office campus (Rock Spring Park, Md.), and a suburban office/ research park (Shady Grove, Md.). Bethesda is an inner suburb that has developed as a mixed use node around the subway station. Rock Spring Park is an office campus located just outside the Capital Beltway and bounded on all sides by freeways. Shady Grove is located outside the Beltway at the suburban terminus of the Metrorail Red Line. Table 1 summarizes the characteristics of the different centers.

Survey Instruments

The surveys in Washington, Bethesda, and Rock Spring Park were administered as part of the Norfolk Downtown People Mover Study led by Douglas and Douglas, Inc. The Shady Grove survey was conducted by Parsons Brinckerhoff Quade and Douglas, Inc., as part of the Rockville-Shady Grove Area Transit/Land Use Study. Each of the four survey instruments contained major sections covering:

Table 1: Summary of area characteristics

Measure	CBD	Suburb CBD	Campus	Park
Employees (000)	400	20	15	16
Density (FAR)	~ 5	~ 1	~ 0.5	~ 0.3
Metrorail Stations	many nearby	one at center	2 miles	1-3 miles
Land Use Mix	full	local	none	none
Pedestrian Environment	very good	good	fair	poor

1. The journey to work;
2. Trips made during the work day;
3. Trips made after work; and
4. Demographic questions.

The Shady Grove Area survey included some additional questions regarding deterrents to transit use and carpooling. Additionally, questions inquiring about the effectiveness of various incentives for transit use and carpooling were included.

Businesses in the study area were separated into two strata based on their tenancy status. Firms occupying 90% or more of a building were placed in a single tenant category which carries with it certain intangibles such as full control over parking. A stratified random sample technique was used in administering the survey to ensure data was collected on employees in both single-tenant and multiple-tenant buildings. The administration was divided into four basic phases: inventory, communication, distribution, and collection.

In the inventory phase, each building in the target area was classified as single tenant or multiple tenant. The approximate number of employees who work in single tenant buildings and multiple tenant buildings were estimated based on building size. Firms were selected randomly from each group until the sampling target was reached. Some firms refused to participate and were dropped from the list.

In the communication phase, building managers and employers were asked for permission to distribute the surveys and to confirm the number of employees at each site. The distribution phase followed immediately with delivery of the survey instruments to the participating employees. After about a week, the collection phase began. Surveys were picked up and reviewed for completeness. Where appropriate, interpretive staff editing was used to make surveys usable.

In total over 8,000 surveys were distributed and approximately 3,000 were returned for an overall response rate of 35%. Table 2 shows the response rates in each of the survey areas.

Demographic Characteristics Of The Employee Population

The surveys included an optional section to determine demographic characteristics of the employee population (gender, age, ethnicity, occupation, auto ownership, income). Most respondents answered these questions. Only when asked about income did the response rate drop off (by 15% in Shady Grove, for example). Clearly this question was appropriately placed, at the end of the survey.

Table 2: Summary of response rates

	CBD	Suburban CBD	Campus	Park	Total
Distributed	2,398	2,163	884	3,299	8,744
Completed	815	782	403	1,027	3,027
% Returned	34%	36%	46%	31%	35%

Similar employment mixes were observed in each area. Table 3 provides a summary of the responses. The portion of respondents indicating they worked in a sales position was greater in the suburban locations than in the downtown.

Household income data was requested in the form of a multiple choice question. As a result, the resulting calculations of mean and median income are very rough. However, they do speak to the similarity of the demographic characteristics of the individuals surveyed. Table 4 presents a summary.

Male employees accounted for 53% of the returns. 47% were from female employees. Proportionally, more female workers responded to the survey in the CBD than in the other areas. Table 5 presents the distribution of respondents by gender.

Findings

Journey-to-work Travel Behavior

In the well-served downtown CBD area, nearly 58% of respondents took transit to work. Another 3.9% of respondents walked to work. This is in sharp contrast to the mode split in the suburban office/research park area where only 3.9% of respondents reported using transit or walking. Table 6 summarizes the responses for journey-to-work mode choice.

Table 3: Summary of reported occupation

Description	CBD	Suburban CBD	Campus	Park	Average
Sales	2.3%	6.6%	14.5%	6.9%	6.6%
Office/Clerical	22.4%	23.9%	24.7%	19.0%	21.9%
Service	1.9%	3.3%	0.3%	4.8%	3.0%
Prof/Tech	67.5%	63.7%	58.0%	65.0%	64.4%
Prod Foreman/Worker	0.8%	1.2%	0.0%	1.1%	0.9%
Other	5.1%	1.3%	2.5%	3.2%	3.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

A recognized contributor to the use of automobiles for commuting purposes is the availability of cheap, convenient parking during the day. In the case of the Rockville-Shady Grove Study Area, virtually every vehicle received parking free to the user (96.7% parked at their office in an employee lot). In contrast, only 27% of downtown CBD employees had free parking. Table 7 shows the relationship between parking cost and respondents reporting they drove to work.

Table 4: Summary of reported annual household income[a]

	CBD	Suburban CBD	Campus	Park
Mean	$47,500	$50,500	$50,500	$71,000
Median	$47,500	$71,500	$71,500	$62,500

a. Figures reported in 1993 dollars.

Midday Travel Behavior

Employees were asked to record data for the first four midday trips after the commuting trip to work. The total midday trips, particularly the trips per employee, seem to decline as the amount of mixed use and density of development declines. The data revealed that employees in the CBD make over 40% more trips than their counterparts in the suburban office/research park. The midday trips for employees represent all trips, by all modes, for all purposes. Figure 1 illustrates the differing midday trip rates of the four areas surveyed.

Table 8 indicates the trip purposes for the midday trips. The data reveal that many more downtown midday trips are for eating or personal business than in the suburban office/research park. The suburban CBD shows similarities with the downtown CBD, while the suburban office campus is similar to the suburban office/research park. The clustered mix of activities at the CBD locations seems to contribute to the ability of the workers to address personal needs during the midday.

Table 5: Gender of respondents

	CBD	Suburban CBD	Campus	Park	Average
Female	60.5%	53.5%	53.7%	46.1%	53.0%
Male	39.5%	45.5%	46.3%	53.9%	47.0%

Table 9 presents a summary of the travel modes used to access midday activities in each of the survey areas. A striking contrast is presented between the use of the automobile versus walking to accomplish midday activities in the suburban office environments as compared to the CBD environments. In the single-use centers there are few destinations within walking distance. In the CBD environments many activities are within walking distance to the places of employment.

Vehicle trip making was calculated for each of the surveyed areas. Vehicle trips are those trips which require an automobile for either the driver or a passenger. The calculated vehicle trips per employee represents the number of vehicle trips generated for each employee, not just those employees who make a trip. This method results in the best picture of the conduct of the overall population. It's easy to notice that the vehicle trips per employee go up dramatically as the density of development declines (Table 10).

The table shows that while more midday

Table 6: Journey-to-work mode shares

	CBD	Suburban CBD	Campus	Park
Auto-Driver	29.3%	76.7%	94.4%	90.5%
Auto-Passenger	6.8%	5.3%	2.7%	5.6%
Transit	57.5%	14.1%	2.7%	2.7%
Walk	3.9%	2.7%	0.2%	0.2%
Other	2.5%	1.2%	0.0%	1.0%
Total	100.0%	100.0%	100.0%	100.0%

trips are made per employee in the CBD areas than in the suburban office areas, these are mostly non-vehicle trips. The result is a much higher vehicle trip rate observed in the suburban office areas than in the CBD areas. When we incorporate the distances traversed in the vehicles, and normalize the resulting vehicle-miles traveled figure for each area to that of the downtown CBD, a very clear picture emerges (Figure 2). Employees in the suburban office/research park generate nearly 15 times the VMT per employee as those in the downtown CBD while making less than 65% as many trips.

Table 7: Auto-drive mode share and parking cost

		CBD	Suburban CBD	Campus	Park
Auto-Driver Share		29.3%	76.7%	94.4%	90.5%
Parking cost	Free	26.9%	47.1%	91.7%	98.3%
	Subsidized	26.9%	21.1%	1.4%	1.6%
	Employee Pays	46.2%	31.8%	6.9%	0.1%

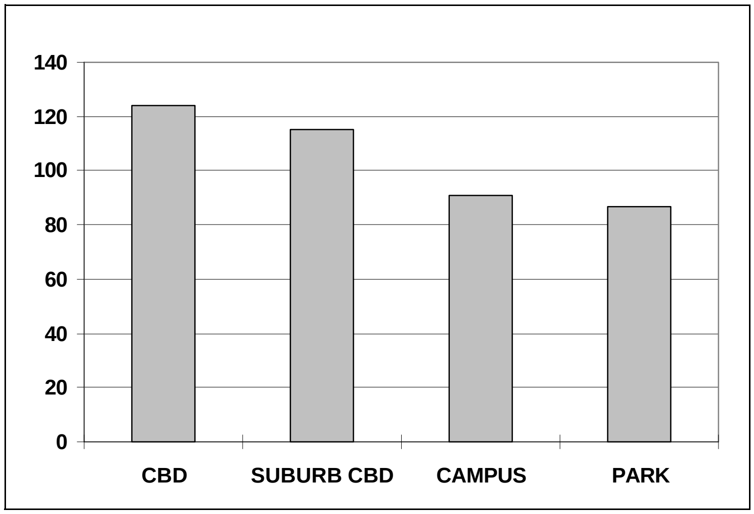

Figure 1: Midday trips per 100 employees

After-work Travel Behavior

The after work travel behavior of commuters was found to be similar across all centers. Roughly 50% of respondents in each area type reported making trips to a place other than home immediately after work. It was thought that the portion of respondents making evening trips might be less in the CBD area types than in the suburban office park environments because at least some of the needs of the employees may have been met during the midday. Instead, it seems that in large part midday trips are not substitutable for evening trips. The major trip purposes of the evening trips were for personal business (31%), shopping (27%), and child care (11%). Perhaps many of the shopping trips are for buying groceries which could not have been purchased during the day, and certainly the majority of the child care trips could not have been substituted with midday travel.

Daily Trip Characteristics

Table 8: Midday trip purpose[a]

Purpose	CBD	Suburban CBD	Campus	Park
Eating	50.7%	46.9%	37.6%	31.1%
Company Business	25.2%	27.5%	41.8%	40.5%
Personal Business	29.7%	28.7%	18.2%	23.7%

a. Figures do not total 100% because more than one trip may be reported during the midday.

It is useful to put the journey-to-work and midday travel information together to draw an overall picture of employee travel behavior in the different areas. The Shady Grove survey asked about trip chaining during the midday and included a more direct method to determine the journey to work travel distance than was used in the other surveys. For purposes of

Table 9: Midday mode shares

	CBD	Suburban CBD	Campus	Park
Auto-Driver	5.6%	23.3%	80.5%	84.0%
Auto-Passenger	1.7%	3.2%	9.3%	5.3%
Transit	8.6%	6.2%	0.0%	0.7%
Walk	80.5%	67.3%	10.2%	8.5%
Other	3.6%	0.0%	0.0%	1.6%
Total	100.0%	100.0%	100.0%	100.0%

illustrating the daily trip characteristics, the Shady Grove statistics for midday vehicle starts per trip and journey to work trip length are used in all areas. It should be noted that the midday vehicle trips in the other areas are similar in character to those in Shady Grove. The average midday trip length in all areas are similar (10 miles CBD, 11 miles Suburban CBD, 8 miles Campus, and 8 miles Park). In Shady Grove, because of intermittent stops, the average number of stops along a journey is 1.4 leading to 2.8 vehicle starts for every trip.

The Shady Grove journey-to-work trip length was about 8 miles each way. Over half of the respondents reported commute trip lengths of over 10 miles each way. Figure 3 shows the travel time distribution among Shady Grove employees.

Table 10: Midday tripmaking

	CBD	Suburban CBD	Campus	Park
Midday Trips per Employee	1.4	1.3	1.2	0.9
Midday Vehicle Trips per Employee	0.1	0.3	1.1	0.8
Midday VMT per Employee	0.9	3.5	6.4	12.7
Midday Trips per Empl. vs. CBD	1.0	0.9	0.9	0.6
Veh. Trips per Empl. vs. CBD	1.0	3.3	11.1	7.8
VMT per Empl. vs. CBD	1.0	4.0	7.5	14.9

The daily vehicle starts per employee is the sum of the midday and commuter vehicle starts. The daily VMT per employee is the sum of the commuter and midday vehicle miles of travel generated. Figure 4 displays daily travel comparisons among the activity centers. The figure shows the difference in total vehicle starts or trips compared to downtown D.C. where transit and pedestrian use sets the basis for low numbers of vehicle trips per person. One explanation for the possible difference between the Rock Spring Park and the Rockville-Shady Grove trip rates is the relative number of attractions within a short drive of Rock Spring Park (e.g., Montgomery Mall, Rockville Pike shopping, White Flint, etc.).

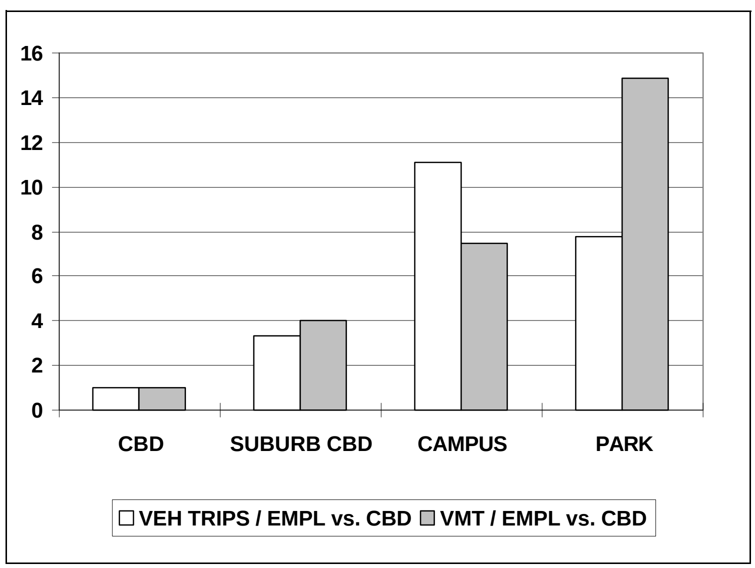

Figure 2: Midday vehicle tripmaking

While there are adequate shopping opportunities in the Rockville-Shady Grove area the relative distance may be just great enough to dissuade people from trying to take care of personal business and shopping during their lunch period.

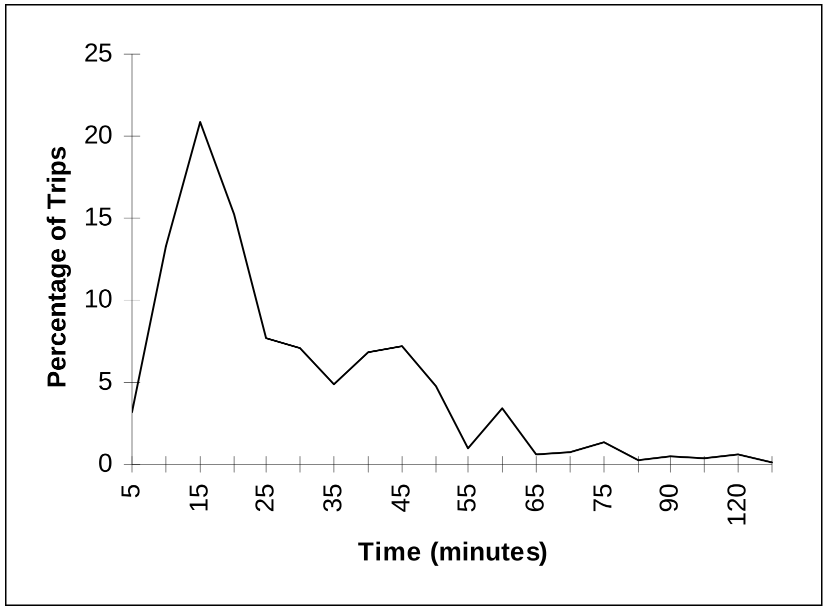

Figure 3: Shady Grove employee commute time distribution

Attitudes About Transit/Carpooling

Although attitude questions were only asked in the Shady Grove survey, it is useful to take a quick look at the findings. When asked why they did not use transit, the 980 auto drivers and passengers surveyed cited the distance from a transit stop as the primary deterrent (37%). Other "primary deterrents" were the need for transportation during work hours (21%), irregular work hours (14%), the expense of transit (13%), and the infrequency of service (8%). Just over 22% of respondents wrote in an "other" reason. Among these were the fact that transit service took too long, was not convenient, involved too many transfers, or was just generally unpleasant.

When asked how likely they would be to take transit to work given a list of incentives, the most remarkable response was that they were not at all likely from 40% to 72% of the time. It will be noticed that the likelihood of inducing transit use through a series of incentives corresponded with the deterrents mentioned. For example, more direct service relative to the employee's residence corresponds with the fact that the primary deterrent to transit is not living near a rail station or a bus stop. Additionally, easier access to transit stops was listed as the second most powerful transit incentive (see Figure 5).

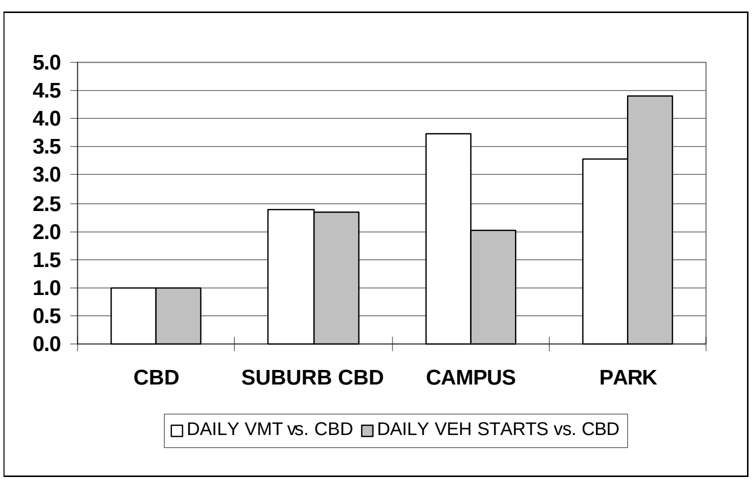

Figure 4: Daily vehicle-miles traveled and vehicle starts

A similar set of questions was asked regarding carpooling. Primary deterrents listed by solo-drivers (90%) were: freedom to have other responsibilities (32%), irregular work hours (32%), and not living near their colleagues (29%). The need for a car for emergencies (18%) and feeling uncomfortable with ones colleagues (1%) were of less concern. Drivers were also asked how likely they would be to join a car pool given a number of incentives. The most enthusiasm

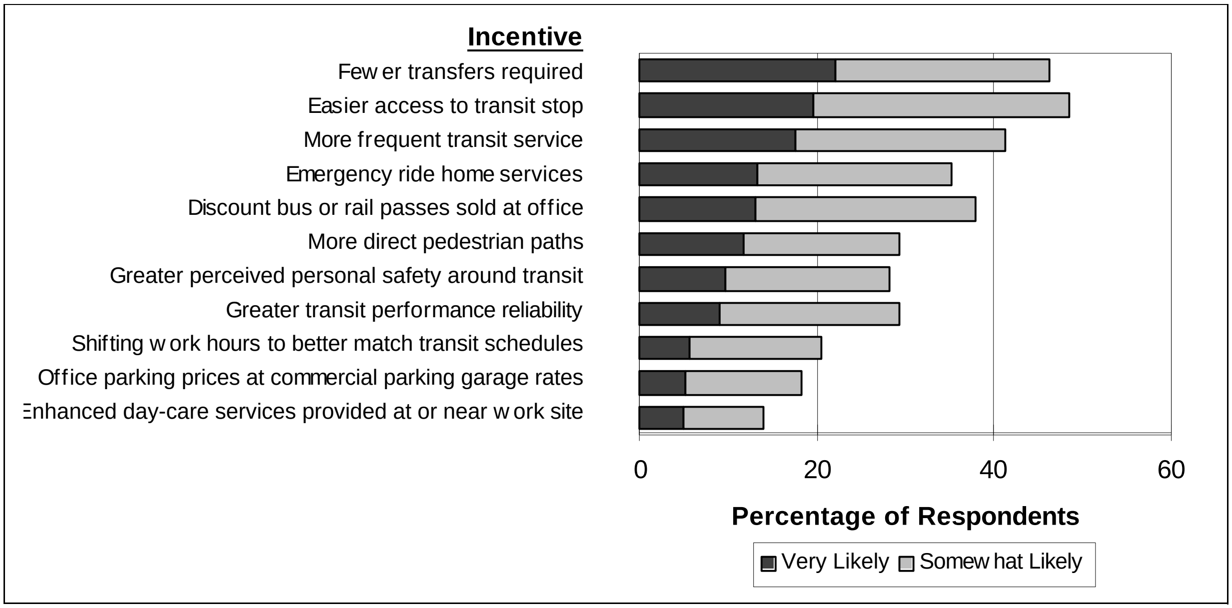

Figure 5: Likelihood to use transit given incentives

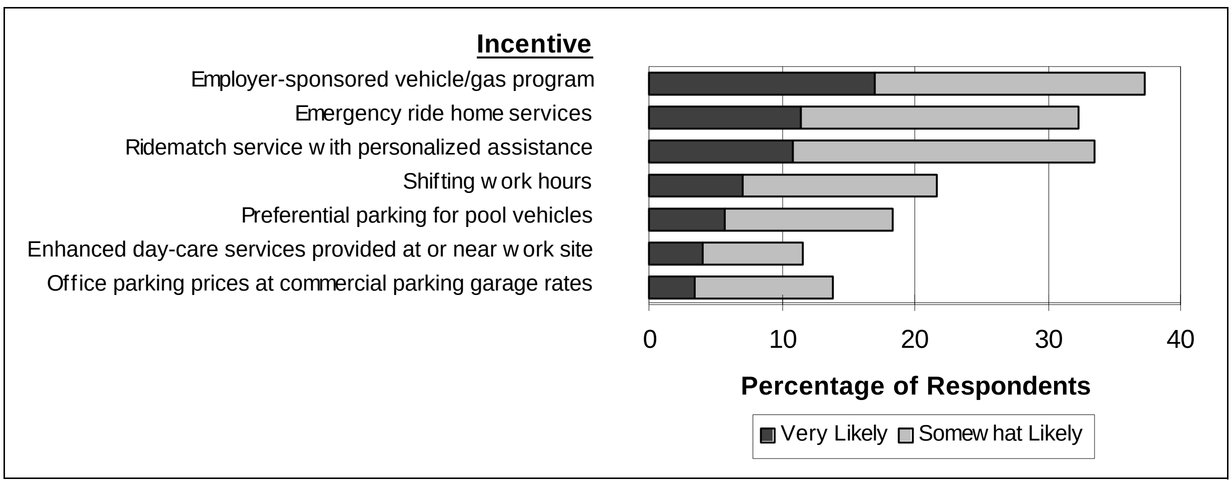

Figure 6: Likelihood to join car/vanpool given incentive

was for an employer sponsored program where the employer supplies the vehicle and/or fuel followed by an employer area wide ride matching service with personalized assistance. Figure 6 illustrates the responses graphically.

Conclusions

The results of the four employee travel surveys conducted in areas with different urban form and urban design characteristics yield two major observations:

- Greater density, mix and size (CBD and Suburban CBD forms) leads to more total trips, more pedestrian trips, more transit trips, fewer automobile trips, and more eating/shopping trips during the midday;

- Less density, mix, and size, (Campus and Park forms) leads to much higher midday vehicular traffic and much higher midday vehicle-miles traveled per employee.

The quality of daytime life for workers in the CBD areas seems better than for the suburban workers. More people are able to leave the building at midday, and they more often leave for non-work activities. These midday trips are often accomplished by walking. In the suburban office settings, most people eat at their desks (63% in the Shady Grove survey). When they do leave the building it is usually on assignment, and it is usually in an automobile. The data suggest dramatic differences in the travel patterns of employees with similar jobs and incomes depending on the urban character of the work place (including mix of land uses).

It is important to note that isolating the causal relationships between trip making and mode choice in relation to individual urban design, urban form and transit service variables proved difficult. The different characteristics of the travel experience seem to relate to these variables in a synergistic format. For example, increased density, increased mix of uses, and high level transit service are often all available at a single site, resulting in a corresponding high-transit mode share and high non-motorized mode share during the midday. Conversely, another site may have a very low mix of uses, poor pedestrian accessibility and poor transit service, leading to either extremely high automobile use or reduced overall trip making. The results of the travel surveys provide an interesting look at the relative differences among trip making in the broad categories of urban form and urban design exemplified by the areas selected.

Safety Benefits of Access Spacing

Herbert S. Levinson, Transportation Consultant; and Jerry S. Gluck, Urbitran Associates, Inc.

Abstract

The spacing of driveways and streets is an important element in roadway planning, design, and operation. Access points are the main source of accidents and congestion. Their location and spacing affects the safety and functional integrity of streets and highways. Too many closely-spaced street and driveway intersections increase accident potential and delays, while too few inhibit access and over-concentrate traffic.

More than 40 years of research has indicated that accident rates increase with the number of intersecting roadways or driveways per mile. As early as 1953, research results showed that accident rates generally increased with both the frequency of access and the average daily traffic; however, the greatest increases resulted from increasing the number of access points per mile. More recent studies in Oregon, Florida, Colorado, and elsewhere found similar relationships.

The consistent pattern of the research results from the above and numerous other studies is clear; the greater the frequency of driveways and streets, the greater the rate of traffic accidents. Increasing the spacing and providing a greater separation of conflict points reduce the number and variety of events to which drivers must respond. This translates into fewer accidents, travel time savings, and preservation of capacity.

The spacing of driveways and streets is an important element in the planning, design, and operation of roadways. Access points are the main source of accidents and congestion. Their location and spacing directly affect the safety and functional integrity of streets and highways. Too many closely-spaced street and driveway intersections, for example, increase accident potential and delays and preclude effective traffic signal coordination. Too few inhibit access and over-concentrate traffic.

This paper describes the results of many research studies that identified the safety benefits of access spacing. These findings provide a basis for establishing sound access spacing practices.

Overview of Research

More than 40 years of research has documented the basic relationships between access and safety. Roadways with full control of access consistently have lower accident rates than other roadways. Accident rates generally increase with greater frequencies of intersections and driveways. Interstate highways with complete control of access consistently experience less than half of the accident rate of other roadways. Arterial roadways with many driveways may have double or triple the accident rates of roadways with wide spacings between access points.

- An early (1953) study by Staffeld on rural two-lane highways in Minnesota found that accident rates generally increased with both the frequency of access and the average daily traffic[1]. Roadways with more than 20 access points per mile had more than double the rates of roadways with less than 4 access points per mile.
- Schoppert (1957) found that the number of access points along rural two-lane highways is a reasonably good predictor of the number of potential accidents within an ADT group[2].

- Head (1959) found that accident rates increased as the number of commercial driveways per mile and/or commercial units per mile increased[3].
- Cribbins (1967) found that as the number of access points and their volumes increased, the total accident and injury rate increased[4].
- A comprehensive study of accident rates on two-lane rural highways was conducted by the Bureau of Public Roads in 1970[5]. Results of the study showed a dramatic increase in accident rates on non-interstate highways as the number of businesses per mile with direct access increased. An increase in the number of businesses per mile, along two-lane rural highways, from 1 to 100 increased the accident rate per million VMT from 1.26 to 17.18.

The growing number of commercial establishments along arterial highways over the past 15 years has been accompanied by increased traffic volumes, congestion and accidents. This led several states and communities to implement access management programs and to conduct additional studies of accidents in relation to access spacing.

A 1995 study by Portland State University for Oregon DOT showed how the accident rates along U.S.1, Coastal Highway, correlate with the number of access points per mile[6]. The results are shown in Figure 1. They show a close and generally consistent relationship between the number of access points per mile and the accidents per million vehicle miles traveled.

As expected, the higher accident rates occur within the city limits where urban development not only results in higher driveway densities, but probably higher driveway volumes as well. The low number of accidents per mile on the Parkway section is explainable by the presence of a continuous non-traversable median. Provisions for U-turns are found at each end of the Parkway section. Comparison of the Parkway section with the section within the city limits illustrates the effective-

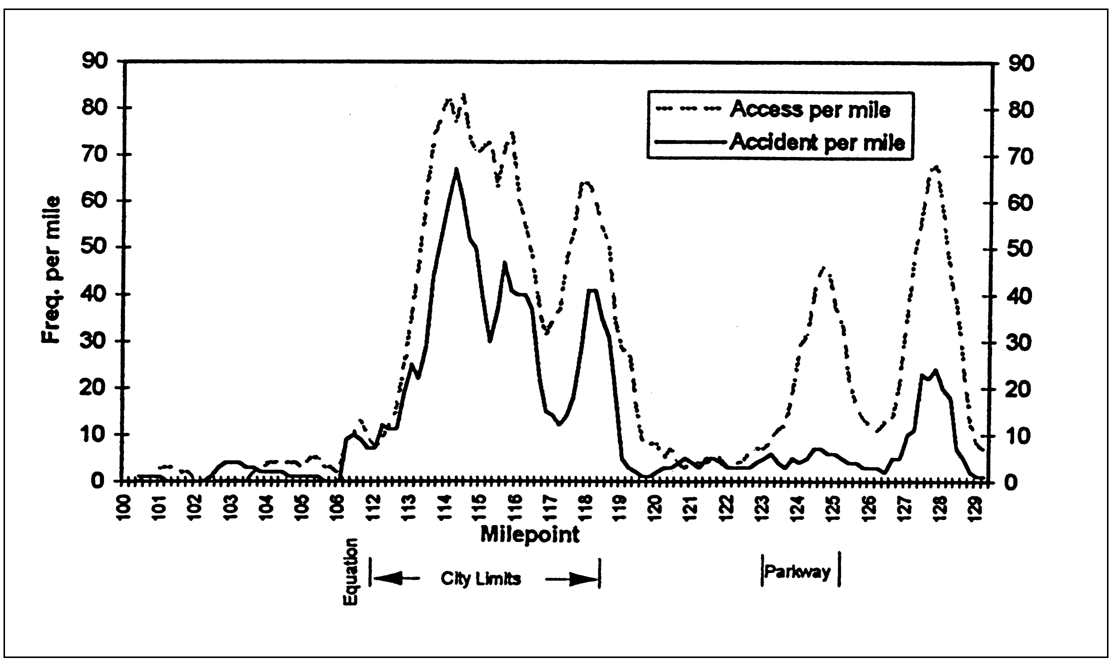

Figure 1: Relationship between accident rates and number of access points per mile on US 101, Oregon

ness of a non-traversable median in reducing accidents despite frequent access connections.

Figure 2 shows how the number of accidents per mile is related to driveway density along Route 7 in Norwalk and Wilton, Connecticut[7]. The data suggest a linear relationship.

Figure 3 illustrates the relationship between access frequency and mid-block accident rates for rural two-lane roadways in Michigan. The accident rate increases directly with the average number of intersections per mile since closer intersection spacing increases friction among vehicles. For the same number of intersections per mile, urban facilities exhibit a higher accident rate; this reflects the higher probability of an accident because of the increased activity[8].

Studies conducted in Florida show an approximate doubling of accident rates, when there are more than 20 to 30 driveways per mile[9,10].

A comprehensive study of how access type, access density, traffic volume and road geometry influence accidents was conducted in British Columbia in 1993[11]. The study covered approximately 750Km of the provincial primary arterial highway network. The individual and joint effects of access and geometric variables on accidents were statistically modeled from which estimated access and accident relationship curves were constructed for each highway category. An

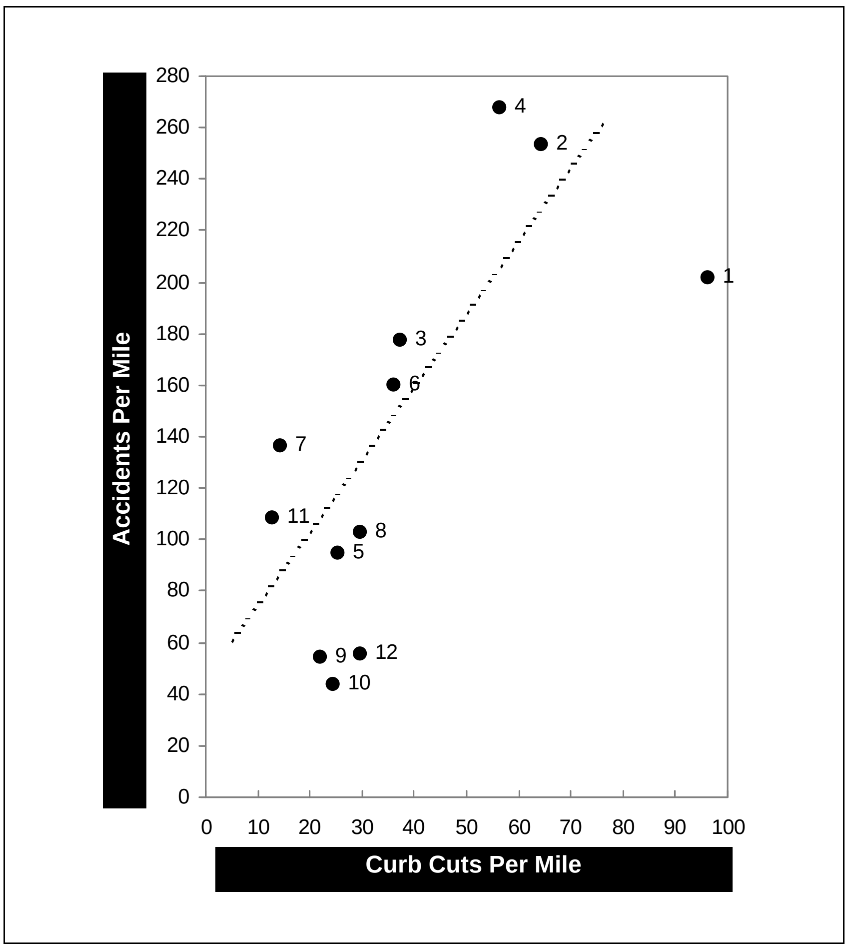

Figure 2: Relationship between Route 7 curb cuts and accident rates per mile, Norwalk-Wilton, CT

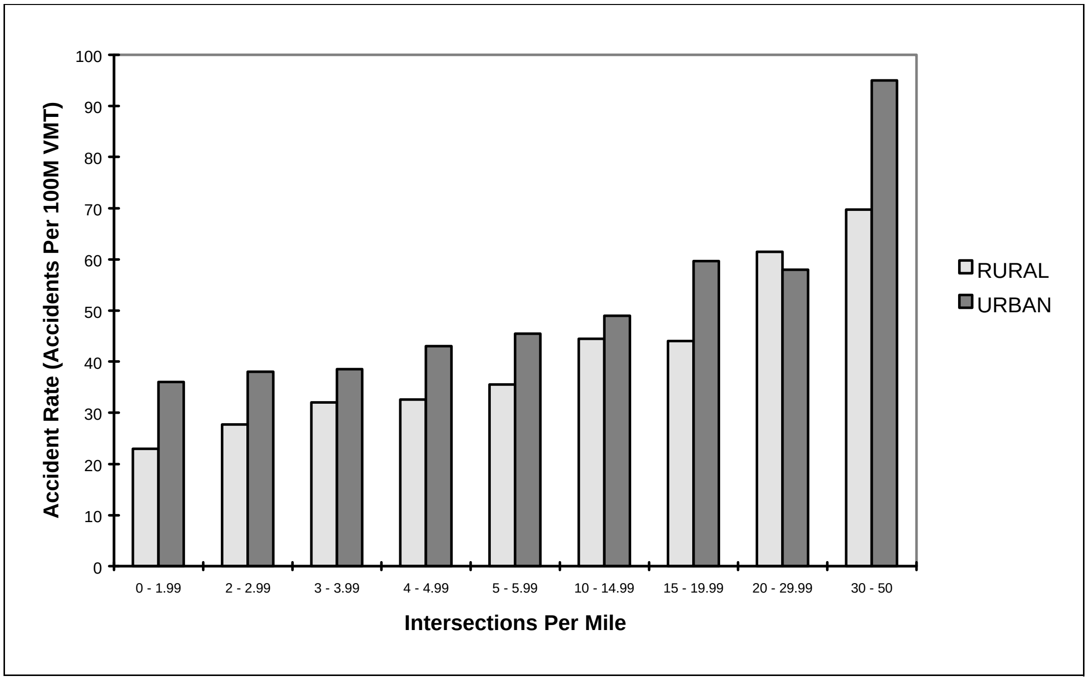

Figure 3: Access related mid-block accidents by trunkline cross section, two-lane undivided roadways, Michigan

increase from 10 to 25 driveways per Km (16 to 40 per mile) resulted in an estimated 85% increase in the accident rate.

Implications and Conclusions

The research results suggest consistent patterns -- the greater the frequency of driveways and streets, the greater the number of accidents. The specific relationships, however, vary reflecting variations in road geometry (curvature, lane-width, presence or absence of turning lanes and medians), travel speeds, and driveway and intersection traffic volumes.

The access spacing implications are clear. Increasing the spacing between access points, and providing a greater separation of conflicts, is desirable to reduce the number and variety of events to which drivers must respond. This translates into fewer accidents, shorter travel times, and preservation of capacity.

Access spacing, therefore, has become an integral part of contemporary access management actions. These plans have produced important safety benefits. Access management plans for 4.35 miles of Arapahoe Road and 5.16 miles of Parker Road in the Denver metropolitan area were implemented in advance of actual development as part of Colorado statewide access management programs[12]. The plans installed physical medians along both roads to separate opposing directions of travel and to limit crossings to designated locations; generally confined full movements to signalized intersections spaced at ½ mile intervals; provided right-turn only access at ¼ mile intervals, although a limited number of special access points were allowed at other locations; and incorporated additional auxiliary right-turn and left-turn lanes at all accesses where medium to high turning volumes were expected within 20 years. The two roads carried more traffic per lane at double the peak hour speeds with half of the accident rate found on several arterials without

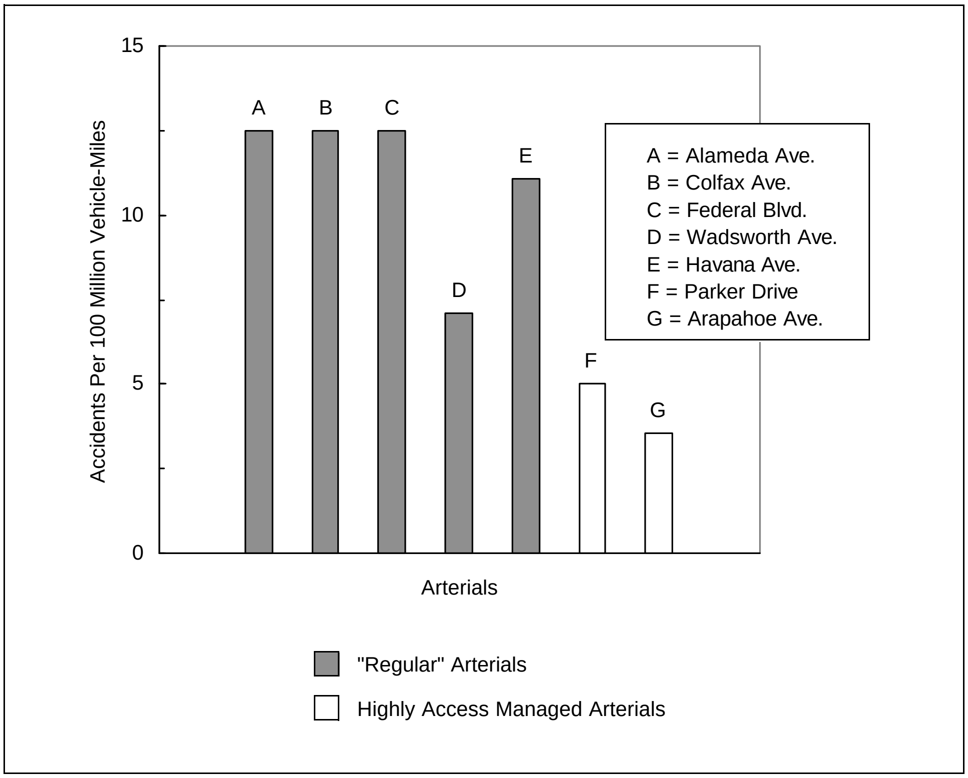

Figure 4: Accident reduction due to access management in Denver, Colorado

access controls. Figure 4 summarizes the reported accident rates.

Wide access spacings allow drivers to better respond to changing conditions by providing more time for driver perception, reaction, and navigation. Both driver behavior and vehicle dynamics are important determinants of access spacing designed to promote safety.

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Access Management in Michigan: "The Good, The Bad, and The Ugly"

David Geiger, Michigan Department of Transportation; Jerry Gluck, Urbitran Associates; and Mark Wyckoff, Planning & Zoning Center

Abstract

An access management study was performed to review the driveway permit process of the Michigan Department of Transportation (MDOT) and identify areas of potential improvement. The study objective was to evaluate MDOT's existing access control policies as they pertain to state trunklines. This evaluation was done to assist in the development of a systematic, overall approach to access management provides a sound legal basis for access control decisions. The approach was tailored to Michigan's particular need — its broad range of road types, development patterns, geography, and political jurisdictions.

This paper outlines the approach used in an assessment of current practices and the findings, the process used in establishing recommendations in conjunction with stakeholders, and the development of implementation scenarios for presentation to and approval by upper MDOT management.

Large-Scale Traffic Microsimulation From An MPO Perspective

Ken Cervenka, North Central Texas Council of Governments

Abstract

One potential advancement of the four-step travel model process is the forecasting and simulation of individual activities and travel. A common concern with such an approach is that the data and computational requirements for a large-scale, regional microsimulation may be so intensive that a successful application would be virtually impossible for a typical Metropolitan Planning Organization (MPO) or other agency to achieve. This paper and presentation will focus on the "big picture" issues surrounding traffic microsimulation, i.e., "is it worth the effort," with the underlying theme being that the level and quality of detail needs to be in line with the particular application that is being addressed.

Much of the information is derived from the work the North Central Texas Council of Governments (NCTCOG), the MPO for the Dallas-Fort Worth region, is doing on the Transportation Analysis and Simulation System (TRANSIMS) project. TRANSIMS is a federally funded project being conducted by Los Alamos National Laboratory to develop a "next generation" travel model. The paper and presentation will include an overview of NCTCOG's involvement in the Traffic Microsimulation Case Study, which represents the first interim operational capability of TRANSIMS. Issues surrounding the required detail and accuracy of network coding and travel data will be discussed, both for existing (observable) and forecast conditions. The need for (and procedures for) calibration and validation on both a micro- and macro- level will be described. Database management techniques for keeping track of all information and the computational and manpower requirements for a successful application will be discussed.

The North Central Texas Council of Governments (NCTCOG) is the Metropolitan Planning Organization (MPO) for the 5,000-square-mile, four-million-person Dallas-Fort Worth Metropolitan Area. Since 1995, we have had the opportunity to work with Los Alamos National Laboratory (LANL) on a case study application of the first interim operational capability of a "next generation" travel simulation and forecasting tool known as the TRansportation ANalysis and SIMulation System (TRANSIMS).

NCTCOG's primary involvement has been with the Traffic Microsimulation module of TRANSIMS. This experience has given NCTCOG new insights about how a large-scale regional microsimulation can be eventually made a part of a typical MPO's transportation planning and decision-making process. While the data requirements for running a microsimulation can be extensive, the underlying theme is that the level and quality of data detail needs only to be in line with the particular application that is being studied.

Following a description of TRANSIMS, the topics covered include the traffic microsimulation process; case study overview; network coding procedures; database management issues; TRANSIMS output analysis; what we have learned so far; next steps; and closing thoughts on microsimulation.

What Is TRANSIMS?

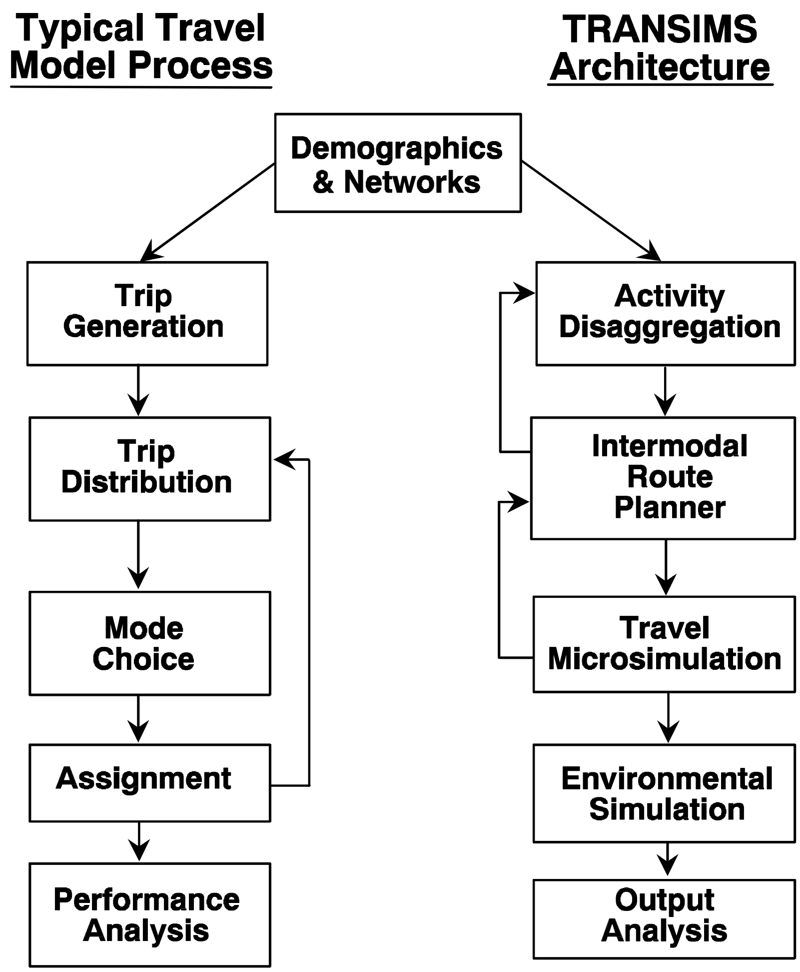
TRANSIMS is a set of integrated tools for simulating individual-level travel on a regional scale.

Although functionally similar to the four-step travel model process of trip generation, trip distribution, mode choice, and assignment (see Figure 1), TRANSIMS is fundamentally different in that it deals with individual travelers rather than zonal and link volume aggregations. This is referred to as a “bottom-up” computational approach because the second-by-second interactions of individual behaviors (e.g., drivers) are used to observe aggregate dynamic (emergent) behaviors.

TRANSIMS is one part of the multi-track, multi-year, federally funded Travel Model Improvement Program (TMIP). Los Alamos National Laboratory is leading the “Track C” research and development effort to develop new approaches that are intended to advance the state-of-the-art of travel modeling. LANL is a federally sponsored scientific institution near Santa Fe, New Mexico that is best known as the developer of the world’s first atomic bomb. Their world-class expertise in large-scale computer simulations was a major selling point in their selection as the prime TRANSIMS contractor.

FIGURE 1

COMPARISON OF APPROACHES



Traffic Microsimulation Process

The Traffic Microsimulation is based on a cellular automata approach in which each lane of each roadway link is sectioned into an array of cells of uniform length (approximately 7.5 meters). Second-by-second movements of vehicles from one cell to another are based on simple probabilistic rules that account for interactions with other vehicles:

- Speed up when you can;
- Slow down when you must;
- Sometimes slow down for no reason at all;
- Change lanes in order to pass slower vehicles;
- Change lanes in order to follow a scheduled trip plan; and
- Change the "minimum acceptable time gap distance" during congested conditions (e.g., to make a left turn in front of opposing traffic).

Although additional (i.e., more complicated) movement rules could be developed, cell sizes decreased, and re-calculations performed more frequently than once a second, this increased level of computation was unnecessary for achieving the objectives of the interim Traffic Microsimulation program.

Case Study Overview

The Dallas-Fort Worth area was selected by LANL in 1995 to be the site for a demonstration of the functionality of the Traffic Microsimulation program. With planning funds provided by the Federal Highway Administration and the Texas Department of Transportation, NCTCOG assisted in the project by:

- Interacting with Los Alamos National Laboratory, the U.S. Department of Transportation, U.S. Environmental Protection Agency, and others to be sure the interests of the potential end users of TRANSIMS are being considered;
- Preparing network, trip table, and traffic data for the case study; and
- Reviewing the output of the case study model runs.

The case study illustrated TRANSIMS' ability to partition the benefits and costs of a transportation infrastructure change among subpopulations of travelers. The primary region of interest for the equity analysis was a 25-square-mile area in north Dallas County, with a focus on a major shopping/business center (the Galleria area).

Network Coding Procedures

The network coding structure consists of a series of files maintained in an Oracle database. Separate tables are used for nodes, links, pocket lanes (e.g., left- or right-turn bays), traffic loading points (the location where a vehicle appears on the network), lane connectivity (e.g., all allowed lane movements at an intersection), traffic signal phasings, and traffic signal timings. Although ArcView was used for network viewing, the initial coding for the case study was based on non-GIS procedures.

The link and node files were derived from a previously developed travel model network (a 1990 "focused" network from the I.H. 635 (LBJ) Major Investment Study) that contains most collector streets and all higher functional classification streets. Since local streets were needed within the 25-square-mile study area, Arc/Info was used to incorporate Census TIGER streets onto the base network. Detailed intersection data was obtained through field checks, information supplied by local traffic engineers, and professional judgment.

Database Management Issues

From the user's perspective, there are legitimate concerns about the extensive network data requirements of TRANSIMS (or any microsimulation approach). Some of the issues for consideration include:

- How much network detail is really needed? If local streets are required, what about non-TIGER driveways and circulator streets?
- How good does the input data need to be? Does it really make a difference whether the lane geometries of every low-volume unsignalized intersection are accurately coded?
- Even if we develop detailed current-year networks, how do we code future-year intersection geometries and signal phasings, timings, and offsets?
- Who has the responsibility for developing and maintaining the databases?

Although use of GIS-based procedures should lead to increased quality/integrity of data, they will not be sufficient to resolve these issues. One strategy for dealing with extensive network detail may be to develop a process in which an initial TRANSIMS-format network can be quickly coded from whatever information is readily available, and then improved over time:

- For initial microsimulation runs on a regional scale, it may not be necessary to conduct extensive field surveys of all signalized and unsignalized intersections. If the number of "mid-block" directional lanes on all roadway links is known (or can be forecasted), intersection data could be synthesized by using profile or default configurations obtained from a sample of intersection observations.
- On an as-needed basis (e.g., for detailed model validation or initiation of local traffic operations studies), the synthesized intersection data can be replaced with observed information.

In other words, the person-hours to be allocated towards intersection coding and other "network cleaning" activities can be tailored to the specific needs of a transportation study. Most intersections in a region could perhaps be initially coded with default or profile configurations, then edited, over time, in a graphical environment. The work related to development of a "network synthetic substitution" procedure has not been completed or sensitivity tested, but is expected to include a series of intersection geometry, signal phasing, and signal timing profiles that vary according to:

- Characteristics of the intersecting streets--functional class (e.g., major arterial versus collector or local), number of "mid-block" lanes in each direction, and traffic volumes in each direction; and
- Local policies, location (land-use, activity density, pedestrian movements), right-of-way con-

straints, and funding.

TRANSIMS Output Analysis

Of equal importance to the issue of the quality of the input network data is the interpretation of the model output. In other words, how do we make sense out of massive amounts of output data? TRANSIMS is capable of generating at least three types of output data:

- Trajectory/evolution data of individual vehicles, by time step (animations, snapshots, etc.);
- Special event data (signal phase failures, long queues, etc.); and
- Summary data (link travel times, variance of travel time, animation of vehicle densities, etc.).

The interpretation of output data is a work-in-progress for the TRANSIMS project. Strategies for organizing and analyzing output data are expected to include the following:

- Since it is practically impossible to collect/analyze all available information, it is important to adopt a goal-oriented information sampling technique. For example, we may be interested in summarizing traditional weekday measures of effectiveness such as vehicle miles and vehicle hours of travel by subarea or subpopulation. We may also be interested in examining new performance measures such as system reliability (e.g., variability of speeds) along specific routes.
- An adaptive data collection technique may also be implemented, in which certain events (such as excessive queues or delays at an intersection) act as automatic triggers for how additional information is stored and presented. Selected data could also be made available to an individual while the simulation is running, so that the user can make on-line adjustments to the information that is being stored.
- A review of three-dimensional traffic flow animations is another way to spot unusual activities that are worthy of more detailed analysis.

What We Have Learned So Far

The “lessons learned” from NCTCOG’s participation with LANL on the case study, so far, include:

- The TRANSIMS’ interim Traffic Microsimulation program works, including its ability to analyze sub-populations and network reliability. LANL’s initial objectives have been achieved.
- The examination of interim programs in a “real world” case study setting has emphasized the importance of feeding microsimulation data back into the trip planner-and ultimately the activity generator.
- The network coding procedures used for the case study were both cumbersome and error prone, and point out the importance of semi-automated (i.e., “expert”) GIS-based procedures.
- Perfect network representations of the real world are practically impossible to achieve, but maybe this doesn’t really matter-we still need to figure out the level of detail and accuracy that’s needed for specific types of transportation studies.

- A traffic microsimulation makes the limitations of other procedures (e.g., network representations, demographic estimates/forecasts, and time-of-day trip distribution) much more apparent.
- Making sense out of massive amounts of output data is not a trivial task.

Next Steps

The next phase of LANL's TRANSIMS development will focus on case study applications in Portland, Oregon. NCTCOG's activities in 1997 and 1998 will continue to center on an examination of the interim Traffic Microsimulation program and its input and output data:

- We will assist LANL with documentation and dissemination of all TRANSIMS-related work that was performed.
- We will continue to work with the available TRANSIMS output data to see how new types of performance measures (measures of effectiveness) can enter into the "mainstream" planning process of future TRANSIMS end-users. Potential new measures for consideration include:
- Traffic flow animations of congested conditions (for visual examination of problems by both planners and decision makers);
  - Vehicle miles and hours of travel on link segments, by speed range;
  - Reliability and variability in link segment speeds and individual trip speeds;
  - Individual vehicle speed profiles from origin to destination;
  - Individual travel identification (for more comprehensive equity analysis);
  - Variations in the actual "passenger car equivalency" of trucks and other low-performance vehicles, under different conditions;
  - The marginal costs (additional vehicle miles and hours of travel) for "just one more vehicle" along a specific origin-destination path;
  - "Snapshot" traffic density;
  - Size and integrity of vehicle platoons;
  - Intersection delay per vehicle (stop delay + approach delay = travel delay);
  - Number and duration of stops (for intersections, link segments, or travelers);
  - Frequency distribution of queue lengths at intersection approach lanes; and
  - Frequency of signal cycle failures (i.e., a stopped vehicle cannot make if through the intersection on the next green phase).
- We will get involved with additional parametric and sensitivity tests of the Traffic Microsimulation:
  - Identify the ability of the interim programs to address Congestion Management and Intelligent Transportation System strategies;
  - Document the current functionality of the interim programs for representing all network input data;
  - Identify the impacts of the provision/removal of local street detail and traffic loading points;
  - Identify the impacts of changes to link segments (speed limit, grades, precision of length, temporary lane closure), intersection geometry (pocket lane lengths, lane-movement configurations, setback distances, addition/deletion of approach lanes), and traffic signals

(offsets, signal phasings, signal plans, and right-turn-on-red restrictions); and
    - Identify the impacts of variations in travel demand and driver/vehicle characteristics.

- We are also very interested in figuring out how to make TRANSIMS easier to use and understand:
    - Additional research and testing is needed to make the "network synthetic substitution" approach more meaningful;
    - We will provide recommendations on database management, as well as goal-oriented information sampling techniques;
    - We will assess the relevance of both interim and "final" programs to specific real world needs; and
    - We will identify potential enhancements to the interim programs.

Closing Thoughts On Microsimulation

Microsimulation of individual-level travel on a regional scale is a field that holds considerable promise for significantly improving existing travel forecasting procedures used by MPOs and other agencies. At this stage of microsimulation research and development, there are still many unanswered questions about whether the increased level of sophistication in procedures will be, ultimately, "worth the effort." Here are some closing thoughts about microsimulation and TRANSIMS:

- A case study approach seems to be a workable idea for research-oriented projects that must also demonstrate real-world results.

- One of the difficulties of something like TRANSIMS is that a lot of the procedures fall outside the normal "comfort zone" of the potential end-users. For example, most transportation planners are unfamiliar with day-to-day traffic operations issues, and most traffic engineers are unfamiliar with travel forecasting procedures. Both groups, however, are aware of the difficulties of gathering detailed and accurate data.

- In order to determine if large-scale microsimulation will ultimately lead to improved decision making, the transportation community (researchers, planners, and traffic engineers) needs to get more involved with an identification and assessment of new analysis tools.

- It's still not clear how much work will be needed to get useful results for a specific transportation study. Will it be ultimately proven that fundamental behaviors are largely transferable between regions, and that all programs can therefore be easily calibrated and validated? The issue for most future users will not be whether decision making is improved, but at what cost.

- Even a "perfect" TRANSIMS process will be limited by the quality of external information. If the results of a year 2020 microsimulation show an extremely clogged network, what does this really mean? Did we mis-specify the intersection coding or traffic loading points, or do we have a problem with our basic demographic assumptions?

An Integrated Traffic Simulation/GIS Platform for the Bruckner Expressway/ Sheridan Expressway Interchange Improvement Project

Vassilios Papayannoulis and Jerry Gluck, Urbitrans Associates

Abstract

The New York State Department of Transportation (NYDOT) has sponsored a study to investigate the problems and deficiencies at the interchange of the Sheridan (SE) and Bruckner (BE) expressways and to recommend alternatives to enhance mobility and improve highway operations, safety, and geometrics.

The BE/SE interchange project integrates the analysis of the interchange with a number of complementary issues that need to shape the formulation of alternatives, including Hunts Point Market access needs, local community concerns and other transportation-related projects.

As part of this project, Urbitrans Associates conducted origin/destination surveys at the Hunts Point Market and the MTA Bridge and Tunnel facilities was well as on the transit lines serving the study corridors to identify travel patterns. The recommended feasible alternatives for the interchange are being evaluated using CORFLO and FRESIM. For this purpose, an innovative approach was developed by interfacing GIS software with the simulation packages to allow for ease of data exchange as well as for informative presentations.

MapInfo for Windows provided the GIS platform for the development of the CORFLO and FRESIM networks, while the LION file maintained by the New York City Department of City Planning (NYCDCP) provided the network skeleton (the LION file was selected over the TIGER file, since it is richer in data and detail for the five New York City boroughs).

Programs were developed to accommodate LION “pseudo” links, uni-directional links as well as exporting the networks from MapInfo to CORFLO and FRESIM formats. THe programs read the pertinent fields for each CORFLO and FRESIM record from the database and stores all the information in an ASCII CORFLO or FRESIM format. After the simulation runs are performed, he output of CORFLO and FRESIM are converted to a database file and are imported in MapInfo for analysis of the results.

This paper provides a description of the integrated simulation/GIS platform as well as the application of CORFLO and FRESIM to evaluate the feasible alternatives for the BE/SE interchange.

Cost Benefits of Exception Reporting Probe Vehicles for Network Surveillance that Support A Dynamic Route Guidance User Service

Allen T. Proper and Karl E. Wunderlich, Mitretek Systems

Abstract

In support of an FHWA-sponsored ITS benefit study, Mitretek Systems is conducting a traffic simulation study that examines the value of traffic information for dynamic route guidance. The study examines the benefit under a wide range of network surveillance ranging from no surveillance to complete surveillance.

This report discusses the results of a study on network surveillance for the support of a dynamic route guidance user service. The purpose of the study is to determine the value of traffic information provided at various levels of network surveillance by measuring travel time performance of dynamically route guided vehicles. Specifically, this paper examines the problems, effects and costs of reducing the opportunity for probe vehicles to report travel time information.

As probe vehicles traverse a network they send their trip time information to a Traffic Management Center (TMC). The cost associated with this increases as probes in the network increase, and reporting stations increase. This report focuses on the reduction in benefit to a dynamically route guided vehicle population as probes are limited to reporting travel time for only subset of links in a network. This method could represent a significant reduction in the cost of communication between probes and the TMC. This however may require that probe vehicles also have some knowledge about network conditions. Therefore, this study also examines the extra cost of supplying probes with more advanced equipment to obtain the required data.

The approach of this study is to employ the INTEGRATION traffic simulation model and a network with both freeway and arterials based on the Cherry Hill, New Jersey area. Measurements for travel time and delay reduction are taken for varying opportunities of probe vehicles to report travel times under incident conditions.

To date, the study has demonstrated that with the network under incident conditions and a five percent unguided probe population reporting travel times for the incident link only, guided vehicles can obtain 90% of the benefit associated with a system reporting travel times for every link. For this scenario, with probes only reporting on the incident link more than 95 percent of the cost of reporting travel times can be saved over that of reporting travel times for every link.

Comparison of FHWA TRAF Simulation Programs and the Highway Capacity Software in Analyzing Impacts on Surface Streets and Freeways

Barbara Arens and Linda Powell, Parsons Brinckerhoff Michigan, Inc.

Abstract

This paper presents the results of comparing various traffic engineering software in analyzing the effects of existing and future traffic demand on arterial streets and freeways. Providing the best analysis for traffic conditions and having a comfort level with the results is a difficult task based on the various methodologies available. Some of the arterial streets analyzed contained one way north- south and east-west pairs. The freeway section analyzed posed an interesting challenge in that the corridor has three freeway to freeway interchanges in less than two miles. The middle freeway to freeway interchange contains both left and right exit ramps. Ramp metering is also present along the corridor.

Traffic simulation software and the Highway Capacity Software (HCS94) were utilized in the analysis of the arterial streets for both existing conditions and future forecasts. The project was originally analyzed with TRAF-CORFLO (NETFLO1), a macroscopic simulation model. TRAF-NETSIM was subsequently utilized in the same corridor. NETSIM is a microscopic simulation model. The TRAF family of simulation models were developed for the Federal Highway Administration. These simulation models were chosen since a network of streets in the downtown core were to be assessed. The models were calibrated for existing conditions based on count data. The 1994 HCS was also utilized on study intersections. TRANSYT-7F was utilized to calculate the fixed time signal timings for the networks.

Three pieces of software were utilized in the freeway analysis due to limitations and comfort level of the reviewing agency; TRAF-FRESIM, FREFLO, and Highway Capacity Software (HCS94). FRESIM is microscopic simulation software, FREFLO is macroscopic simulation software, and HCS is based on the Highway Capacity Manual. Providing the best analysis of traffic conditions and having a comfort level with the results is a difficult task based on the various methodologies available. Both existing conditions and future forecasts were to be performed using traffic simulation software and as a check the HCS94. The models were calibrated for existing conditions based on counts, headway data, and origin-destination data collected as part of the study. The 1994 HCS sections on weaving and ramp and ramp junctions were utilized.

The results, comparisons, and flaws encountered using the various FHWA TRAF simulation programs and the HCS for assessing a network of arterial streets and a freeway corridor will be presented. The objective was to find out whether the results of simulating the same traffic network with the different software were similar. The software employs different approaches to assess traffic flow on urban arterial streets and urban freeway corridors. Measures of effectiveness (MOEs) such as delay, speed, and queue length are compared between the software results.

Evaluation of Planning Issues Using Microscopic Simulation

Michel Van Aerde, Queen's University

Abstract

The past decade has seen a convergence of methodologies for performing traffic operations analyses and transportation planning studies. Specifically, the areas of potential impact of operational studies has grown to also consider in greater detail upstream and downstream intersections, as well as diversion to parallel routes or to other time periods. Similarly, the planning horizon of planning studies has come down to much shorter time frames, such that the treatment of traffic congestion and operational details of different planning alternatives has become more critical. Of particular interest in this regard is the estimation of air pollution impacts of different alternatives, which on one hand are dependent upon such macro features of travel as latent or induced demand, while also being dependent upon micro features such as the number and type of accelerations of vehicles at traffic bottlenecks.

The objective of this presentation is to illustrate how a new family of traffic engineering and planning tools have come to bridge the associated gap in analytical tools. Specifically, the INTEGRATION simulation/traffic assignment model is presented as a practical tool for performing hybrid transportation planning and traffic operations studies. The nature in which gap acceptance, lane changing and car following logic is fully integrated with time-varying traffic assignment and modal split analysis, is illustrated. The application of these new tools is demonstrated using a range of sample analyses ranging from networks as small as a single intersection, to networks covering complete metropolitan urban areas.

The Learning Curve for Successful Selection and Implementation for Enhancement Projects in Michigan

Paul W. McAllister, Michigan Department of Transportation

Abstract

The Federal Highway Administration funded Transportation Enhancement Program is a setaside program for ten specific activities such as landscaping and streetscaping; bicycle and pedestrian facilities; preservation of historic transportation structures; and highway runoff mitigation. Michigan's Transportation Enhancement Program has been very successful in identifying and distributing funds for projects. Four hundred-thirty-three enhancement projects have been selected throughout the state. The program was primarily implemented using existing staff and procedures. While the selection of projects has gone relatively smoothly, the learning curve for implementation of projects was steep both for MDOT and local agencies. Today, the selection and implementation of projects is going smoothly and projects are being constructed quickly.

This paper will discuss the details of the selection and implementation process of enhancement projects in Michigan, with a special emphasis on what has and has not been successful. Some early decisions have worked out, others did not and have had to be modified as the program developed.

Some of the issues to be discussed include:

- The program has been the testing ground for innovative project administration practices by allowing local agencies to let and manage their own enhancement projects. This new way of working with local agencies will be extended to other kinds of projects based on this experience.
- The annual call for enhancement projects has allowed MDOT to modify the program to improve its effectiveness, and to work with local agencies in the development of projects on an ongoing basis. It also allows for the debriefing of unsuccessful applicants, and the resubmission of reworked applications.
- The program has been coordinated with MPOs statewide, but it has been a struggle under the existing criteria to identify adequate numbers of urban projects.

Overall, Michigan's experience with the Enhancement Program has been a positive, community building program that has identified new customers for transportation, and new allies in providing adequate resources for transportation. It has also provided us with a new perspective on our transportation needs and the desires of our communities.

Georgia's Rural Transportation Planning Tool: Something Old, Something New...

George D. Mazur and Wayne A. Sarasua, Georgia Institute of Technology

Abstract

Since the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA), excitement about multimodal planning continues to grow. However, evaluation tools to undertake multimodal planning are still in development, with capabilities for full economic analysis, common performance evaluation, and cross- modal prioritization still several years away. Multimodal planning tools are particularly lacking in rural areas where systematic data collection efforts, forecasting capabilities, planning resources, and even non-auto travel options are typically quite limited.

The Georgia Department of Transportation (GDOT) recognized this lack of systematic, multimodal planning capabilities outside of MPOs and undertook a research effort to develop a computerized transportation planning tool for rural and small urban areas. This tool has capabilities to evaluate and prioritize systemwide needs within six different modes, evaluate specific enhancements on roadway projects, and increase the quality of information available to decision makers.

Tool development is proceeding in incremental fashion, with the first phase relying on existing GDOT planning procedures, and other sketch planning techniques which use existing data. The second phase will incorporate a GIS interface and planning platform, relational database structure and enhanced data collection to improve project-level planning, allow additional planning routines, and allow enhanced environmental screening. The third phase is planned to incorporate consistent economic evaluation routines to eventually facilitate cross modal prioritization.

This presentation and paper will focus on the capabilities provided by the first phase of model development. A demonstration of analysis capabilities and information output will be provided. The planned approach for subsequent phases of model development, and the capabilities to be provided by model enhancements will be discussed. Finally, resource commitments and departmental modifications which are accompanying tool implementation will be highlighted. It is planned for this presentation to occur in an "informal manner", allowing for an open exchange of ideas and experiences between the presenters and the audience.

Business Planning in a Period of Change and Uncertainty at the Michigan Department of Transportation

Hyun-A Park, and Lance Neumann, Cambridge Systematics; and Terry Gotts,
Michigan Department of Transportation

Abstract

Transportation agencies in the United States are facing dynamic demographic, economic and technological changes. Emerging industries, new technologies, and an increasingly global economy are shaping tomorrow's business decisions affecting transportation. Population growth and shifting economic, demographic and travel patterns necessitate creative new approaches to maintaining mobility. In addition, future directions for the transportation system itself have changed. With an extensive network of infrastructure now in place, many agencies must shift priorities from expansion to maintaining and preserving investment, and targeting services to meet emerging demands.

The Michigan Department of Transportation (MDOT) is in the midst of a transformation from a traditional state department of transportation driven by bureaucracy and organizational hierarchy to a progressive organization with fewer layers where decisions are driven by customer priorities. MDOT has undertaken numerous activities over the past few years to achieve this transformation. Some of these activities include extensive use of total quality principles and training, business process reengineering and redesign efforts, and a major emphasis on the development and use of information technology tools as an enabler of change.

In 1995, MDOT initiated a business planning process to develop a long and short term plan of action for meeting its mission, vision, goals and objectives. A key objective of this effort was to develop a comprehensive strategy for MDOT to move into the 21st century. The challenge was to determine the implied strategies from the many activities already underway at MDOT as well as new strategies for future activities. Communicating this message in a clear and concise way to a variety of audiences was recognized as a key factor in the success of this effort.

The completion of the business plan resulted in the alignment of MDOT's business strategy from the mission and vision to specific actions. A short version of the business plan is being published for distribution to all MDOT staff, the Legislature and other interested parties. A longer version of the business plan is being used by MDOT senior management as a strategic guide for decision-making. An electronic version of the business plan is being finalized for inclusion in MDOT's bulletin board and home page. This business plan is providing the strategic framework for how MDOT intends to carry out its activities over the next few years. The likely outcome from the release of these products will be a better understanding of MDOT's business and its future direction by MDOT staff and interested parties outside of the organization. The MDOT business planning process demonstrated the importance of developing a strategic framework for an organization of MDOT's size and breadth. This framework will be an organizing element in MDOT's shift towards measuring its performance and using these results for improving the value of its services to its customers. The business planning process also identified gaps in MDOT's strategic activities which resulted in quick action by MDOT management to cover the gaps. Future business planning exercises at MDOT will benefit from the extensive strategy development work which built the foundation of the business plan.

Transportation Service Center Analysis Using GIS Technology

Glenn C. Robinson, Stephanie Mcdonald and Richard Nellett,
Michigan Department of Transportation

Abstract

Transportation Service Centers (TSCs) were conceived of as a way to organize the Michigan Department of Transportation (MDOT) to better serve the department's core business processes and improve costumer service. The TSCs are local MDOT offices that will be multi functional, multi modal and the primary focus for MDOT's external customer contact. The department's goal is to locate TSCs so that no employee will drive more than one hour to get from their office to a work site and every costumer will be within sixty minutes of a TSC.

The TSC concept originated as a result of the department's evaluation of its key business processes and its commitment to improve the quality of the goods and services it provides. Based on that evaluation it was determined that the best way to meet MDOT's objectives would be to realign the department's activities within the TSC framework. Each functional group within the department was asked to review the activities that they currently perform and determine which might be better handled at the TSC level. Realignment groups were formed so that proposals could be analyzed and implemented as quickly as possible.

Three pilot TSCs locations were put into service during August of 1996. They are 75% functional within the current labor agreements. In April 1997 an additional 12 TSCs will be implemented with a minimum of 50% of those being 100% functional. By March 1999 it is anticipated that all TSCs will be operational.

This paper and presentation outlines MDOT's Travel Demand Analysis Section (TDA) utilization of the Statewide Travel Demand Model and TransCAD's GIS and travel demand modeling capabilities to provide technical support to this reorganization effort. The combination of providing data and profiles along with the ability to illustrate this data with maps and graphs, was very useful in communicating the findings to MDOT management and the MDOT work force.

Included in this presentation and paper are what technical procedures worked and what didn't, what was effective in communicating results to others, and suggestions on how the process can be improved.

Analyses performed include geocoding and mapping the locations of potential TSCs, Regional Centers and employee home and business locations using TransCAD's address matching capabilities; using TransCAD's partitioning procedure to calculate the population within 10 minute travel time increments and the percent of the total state population served within these time bands; and calculation of the average travel time to work for existing employees.

The Transportation Service Center (TSC) concept originated as a result of the department's evaluation of its key business processes and its commitment to improve the quality of the goods and services it provides. TSCs are local Michigan Department of Transportation (MDOT) offices that are multi functional, multi modal and the primary focus for MDOT's external customer contact. The final goal is to locate TSCs so that no employee will drive more than one hour to get from their office to a work site and every customer will be within sixty minutes of a TSC. The original proposal required analyzing thirty-two locations.

The eight core business processes that provided the impetus for this concept include:

- Develop partnerships between MDOT and its customers in order to build a consensus on what transportation improvements are needed.
- Good, consistent communication internally and externally to increase understanding and confidence in MDOT.
- Focus on preserving and optimizing the existing system emphasizing safety and cost-effectiveness with a system wide, multi modal approach to project selection with an emphasis on value added.
- With a commitment to basic mobility, rationalize the transportation system at the state level adding or eliminating elements to ensure those of statewide importance are included.
- Seek agreements with partners which allow MDOT to provide policy direction for state-funded but locally-owned transportation facilities and services.
- Develop and implement innovative transportation system technologies including management systems, real-time traveler information, and intelligent transportation systems.
- Pro-actively seek more appropriate regulatory environments, alternative sources of funding and innovative methods to reduce costs.
- Prepare MDOT personnel to accept these challenges.

An examination of these processes suggested that the best way to meet MDOT's objectives would be to realign the department's activities within the TSC framework. Each functional group within the department was asked to review the activities that they currently perform and determine which might be better handled at the TSC level. Realignment groups were formed so that proposals could be analyzed and implemented as quickly as possible.

There are three pilot TSCs locations, Howell, Swartz Creek and Ishpeming) They currently offer only selected services. They were implemented in August of 1996 and are 75% functional within the current labor agreements. In April 1997 an additional 12 TSCs will be implemented with a minimum of 50% of those being 100% functional. By March 1999 it is anticipated that all TSCs will be operational.

This paper outlines the use of MDOT's Statewide Travel Demand Model and TransCAD's GIS modeling capabilities to provide technical support to this effort.

The TransCAD analysis performed included:

- Geocoding the locations of potential TSCs, Regional Centers, employee home and business locations using TransCAD's address matching capabilities.
- Using TransCAD's partioning procedures to calculate the population within 10 minute travel time increments and calculating the percent of total state population served within these time bands.
- In addition to the population service issue the department was also concerned with the impact decentralization would have on its employees. MDOT's Statewide Travel Demand Model and

TransCAD procedures were used to calculate the average travel time to work of existing employees.

Technical Process

MDOT completed the analysis for this project with the Caliper Corporation's 3.0 Windows version of TransCAD. TransCAD is a complete travel demand modeling package within a GIS framework. TransCAD embodies a concept known as "Tight Integration." A tight integration design bundles together geographic information techniques, database techniques, and modeling techniques into one bundle. TransCAD also includes a procedural tool kit and a scripting language for integrating procedures developed outside of TransCAD into the TransCAD environment.

MDOT'S statewide model zonal and network database layers provided the input data required for most of the analysis used in this project. Maps and reports were generated within TransCAD and outputs were sent to other databases or spreadsheets for further analysis or graphing.

Michigan's statewide model divides the state into 2307 geographic areas called traffic analysis zones (TAZ's). In addition, TAZ's for the rest of the United States, Canada, and Mexico are included. Within Michigan's urban areas the Statewide zones are combinations of urban model zones. In non-urban areas, the zones are typically Minor Civil Divisions. Population and employment data from the Census and other sources are aggregated into the individual TAZ's for use by the travel demand model and for other analysis. For this project, zone numbers were attached to the MPO, Transit Agency and Region address records as well as the employee home and work addresses.

The Statewide Model network includes 9,600 miles of state trunkline system and 11,600 miles of county roads and city streets. There are 7,625 nodes (intersections) and more than 11,000 links (road segments). A zone to zone travel time matrix was created using the length and speeds on the highway network allowing for the calculation of home to work travel times from the employee address file.

The technical process includes:

The input data files contained the employees home and business address locations, as well as the addresses of potential TSCs and the addresses of client agencies (transit agencies, MPO's and Planning and Development Regions). TransCAD's address matching procedures were used to geocode all address locations. The latitude and longitude for unmatched addresses were manually determined. TransCAD's network partioning procedures were used to calculate the population within a 10, 20, 30, 40, 50 and 60 minute travel time bands. TransCad charting and mapping procedures were used to summarize the percent of the total state population served by time bands and regions. The travel time matrix from the statewide model was used to estimate the travel time to work for MDOT employees.

Address Matching / Geocoding

In order to ensure the address matching would go as smoothly as possible all data bases were edited to resemble the Caliper CD address format (the street number street name city and zip code are in separate columns). A data base of existing state employees which included both the home and work address (TransCad\Network\Stwd\Emp_site.dbf) was created from personnel files.

MDOT client address files were also generated. They included transit agencies (Taz\Mast_Tran.dbf), MPO's (Taz\3C.dbf) and Planning and Economic Development Regions (Taz\region.dbf). The format of each file follows.

While address matching in TransCAD is relatively simple, the outcome is not always satisfactory. This may be for one of a number of reasons including:

- The address format was incorrect
- The street name was not contained within the street file
- The employee address was misspelled
- The P.O. Box was non-uniform format
- The zip code was not contained within the Geographic file
- The zip code was incorrect

(Note - With ALL of the files, the address match procedure was used first *and then* we resorted to other procedures using ONLY the remaining unmatched records.)

TransCAD Address Matching Procedures

Locate by Address Procedure:

The process of address matching often requires several iterations. The first iteration used TransCad's automated address matching procedures. The procedure checks for matches by referring to the database and the street file for the number of the house, the street name, the city name, the state name and the zip code. When a match is found then that longitude and latitude are automatically assigned to the record. To resolve near identical matches the user may exercise the option to select manually. A selection set called "unmatched records" is created to store any records that are not matched. Manual tactics were used alternatively to assist the packaged address matching procedures to find matches and to geocode the remaining records (address matching failures are attributed to quality of the census file.)

Search on a Single Address Procedure:

Because the final goal is to find a latitude and longitude for all the records, we proceeded to experiment with other forms of geocoding for unmatched records. Search on a Single Address was one of those procedures used to match the unmatched records. This search allows the user, to search for a single address. Although the information required is identical to that of the Locate by Address Procedure, this approach was successfully used to increase the number of matches.

Within the 1995 Caliper Street CD Layer several street attributes are missing. For example some streets which have names fall outside of the know address ranges and the address ranges are not current. This problem is attributed to the quality of available census data. Efforts are underway to correct this problem in the state of Michigan (Michigan Frameworks Project). Other problems that required additional efforts are: the existence of "unmatched streets links", incorrect spellings and missing address house numbers. In these types of situations the user may match to the closest address. This is not a program glitch, but an insufficient information problem, within the Caliper 1995 Street.cdf. These "unknown" links also appeared in the address match procedure, but only when the option, "ask if uncertain" was chosen before running time. Unknown links were not chosen. The project team could not reliably determine which of the many unknown links to select without looking at the Caliper 1995 Street.cdf. This would have required a considerable investment in man-hours.

Locate by Zip Procedure:

In this procedure the software refers directly to the zip codes in the Caliper Geographic database. This geocoding approach is not as geographically specific as the Locate by Address procedure. When entering the zip code to be located, the person has a choice of the following locating options: locate at zip code area center, scatter inside the zip code area, or scattered near the center. Next the procedure uses the selected unmatched records to compare against Caliper's geographic file to find additional zip code matches. This option was used to complete the employee location map for unmatched records as the product was only intended to give a general picture of the distribution of state employees and specific locations for all records were not considered critical.

The information in Table 1 provides a sense of the relative efficiency of the various approaches used.

Table 1: Efficiency of various address matching procedures

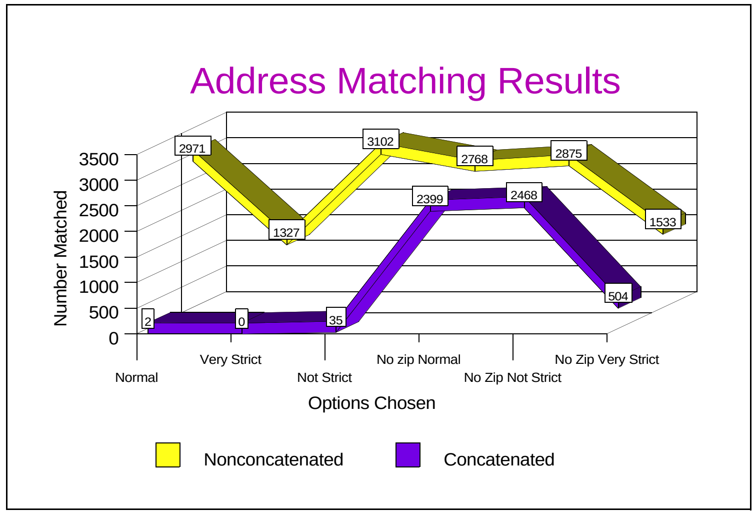
Procedure	Matched Employee Res	Unmatched Employee Res	% Matched
Add_match (normal)	2971	748	73%
Add_match (normal.c)	2	3717	.05%
Add_match (strict)	1327	2392	36%
Add_match (strict.c)	0	3719	0%
Add_match (n-strict)	3102	616	83%
Add_match (n-strict.c)	35	3648	94%
Add_match (no zip) & (normal)	2768	951	74%
Add_match (no zip) & (normal.c)	2399	1320	65%
Add_match (no zip) & (n-strict)	2875	844	77%
Add_match (no zip) & (n-strict.c)	2468	1251	65%
Add-match (no zip) & (strict)	1533	2186	41%
Add-match (no zip) & (strict.c)	504	3215	14%

The Do's and Don'ts of Address Matching

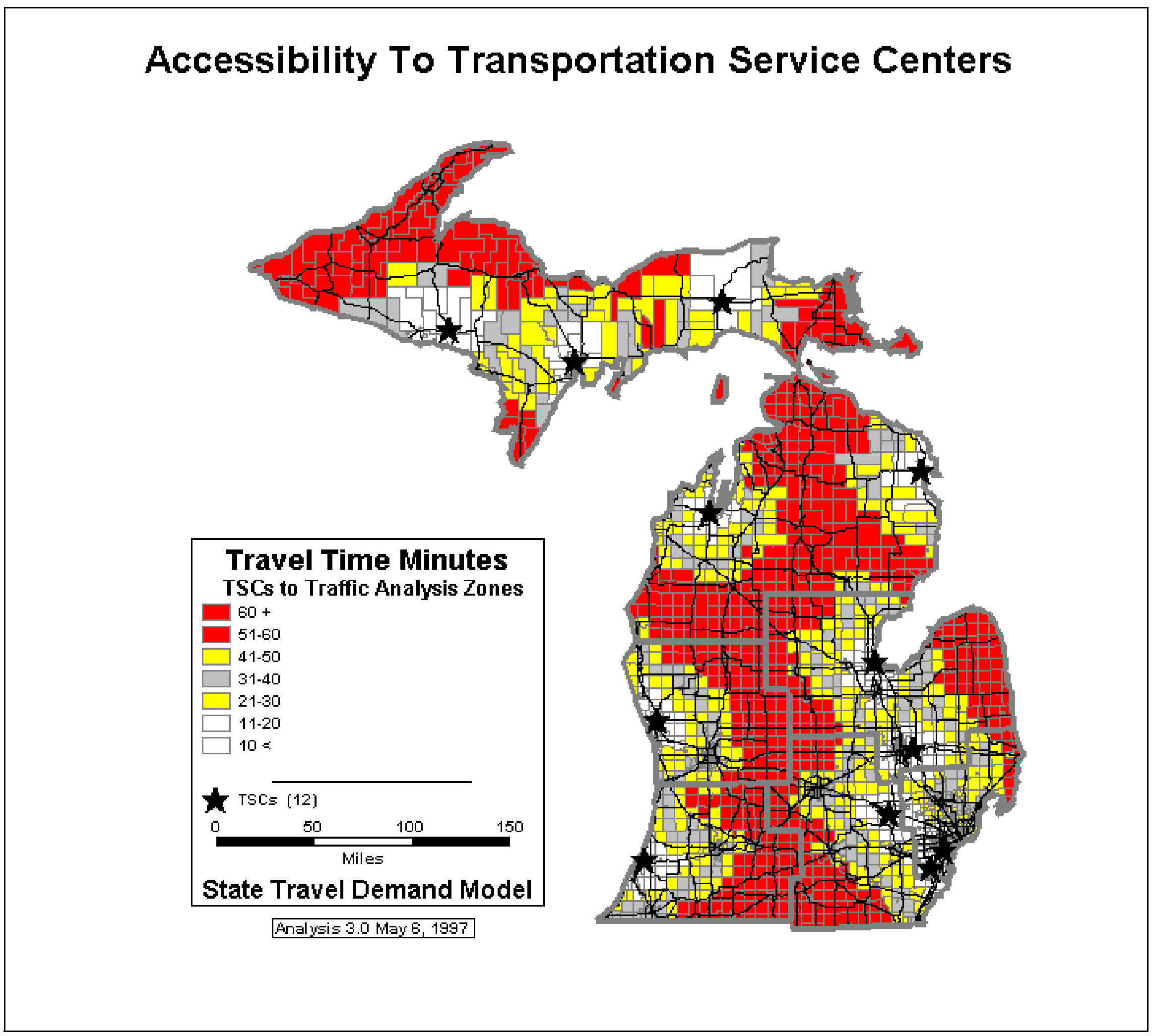
The Must Do's:

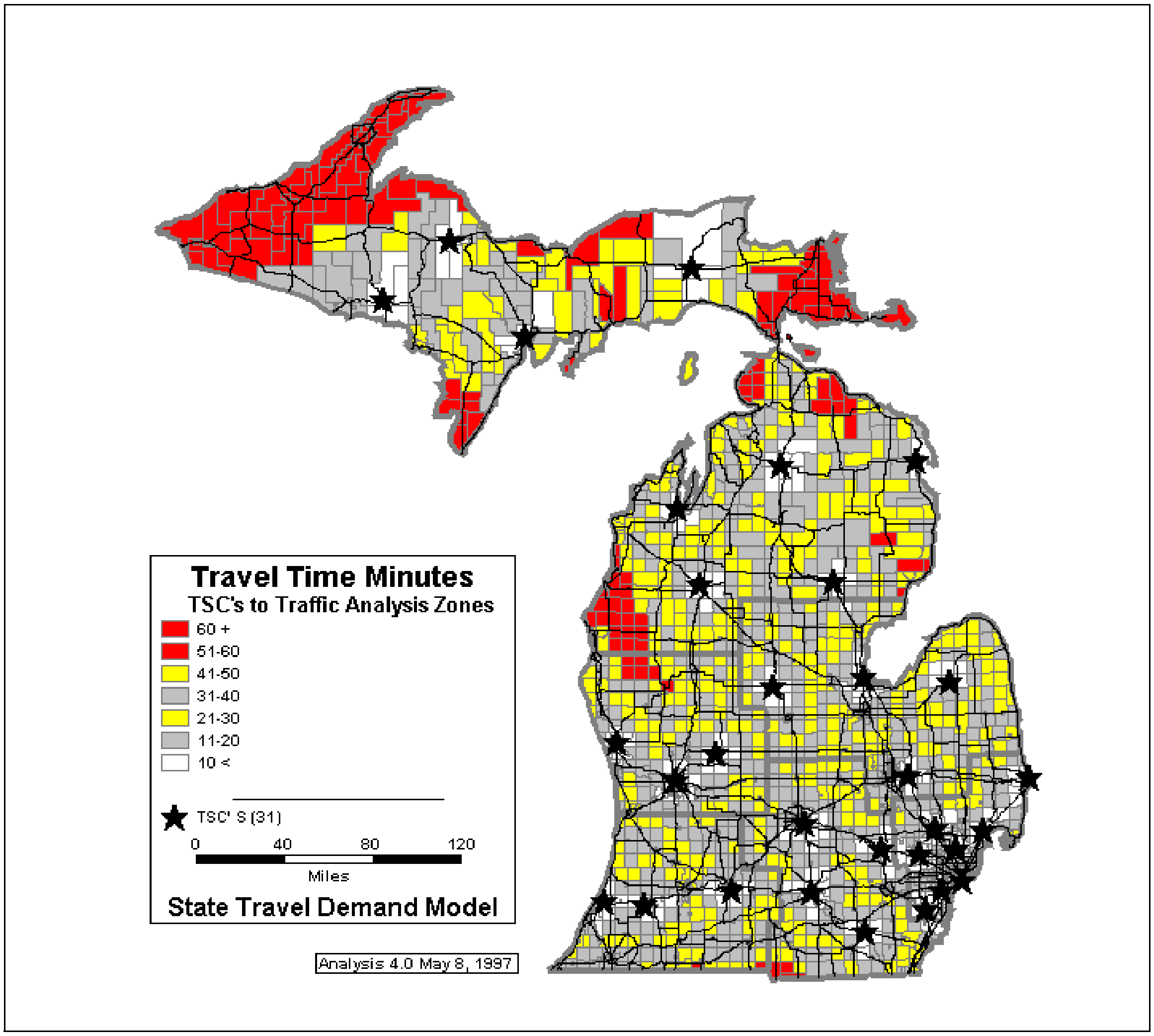
- Edit all addresses in the master database so that the direction of the street comes before the street name, and do not use periods after the direction.
- When a record comes up unmatched check the spelling of all components in the address and check to see if the zip code is correct.
- Make sure that all P.O. Box addresses are uniform to the Information source, to which it will be matched. (For example using a period after the direction of the road: S. Smith Street vs S Smith Street)
- After running the address match procedure save the unmatched records data view. It is more efficient than repeatedly reselecting, with the select by condition function, those without latitude or longitude.
- If the procedure crashes repeatedly and your on a server, that may be the source of a conflict. Try signing off the server and repeating the process.

Address Match Analysis Results



The Figure at the right shows all of the options available while using the address match procedure. It also shows which options produced the highest matched results. Two different address structures were used in running the procedure, a concatenated address which has the house number and street name in one field and a nonconcatenated address which has the house number and the street name in two separate fields. Having these two different formats of the address allowed us to use additional information during the address matching procedure. The concatenated address matched fewer records in every case.





Network Partitioning Procedure

TransCad's network partitioning procedure was used to identify distance bands for each of the TSCs and the population served within each distance band. Distance bands used were 10, 20, 30, 40, 50, and 60 minutes. This procedure was also used to produce maps of accessibility and too evaluate the effectiveness of the proposed TSCs in serving the general population. The steps used in the procedure are described in four phases.

Phase I

Setup

Select nodes that represent TSC locations

Build network based travel times

Phase II

Run network partition procedure setting time bands set at 600, 60, 50, 40, 30 20 and 10 minutes.

Build selection sets for each time band

Phase III

Run select by location procedure. This procedures id's the zones nearest to each network based time band.

Combine travel time set to establish travel time intervals.

Phase IV

Create subsets by regions for each time band. There are 7 regions and 7 time bands.

Build spread sheet to determine % population served by travel time.

Results and Observations

The following maps and tables show the results of the partitioning process. The network travel time represents total door to door trips under typical conditions and congestion levels. It also assumes that drivers do not exceed the speed limit. Travel is to the center of the traffic analysis zone and population is based on the 1990 census block data and aggregated to Michigan's traffic analysis zones. This project analyzed two scenarios.

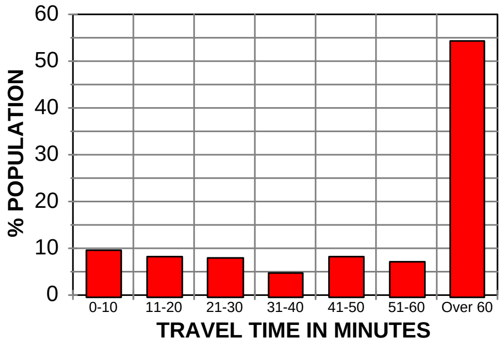
The first scenario evaluated 12 potential Transportation Service Center locations and the second scenario evaluated 31 TSC locations to determine customer and employee accessibility. The goal of the analysis was to determine if the potential TSC locations provide a maximum 60 minute drive time to a TSC for most Michigan citizens. As shown in analysis group 3.0 and analysis group 4.0 approximately 8.5% and 1.3% respectively, of the population have drive times to TSCs that are greater than 60 minutes.

Next Steps and Future Directions

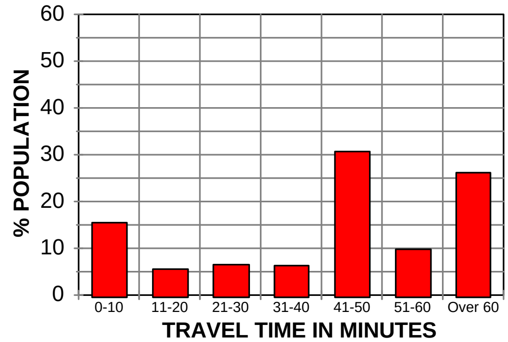
The next step and future direction will be to further automate the network partitioning process. This will enable the STWD planning unit to reduce the time required to provide MDOT's management with a powerful and robust spatial analysis decision making support tool.

Region summaries: Analysis Group 3 (12 TSCs)
Percent of population served by travel time

SUPERIOR



NORTH



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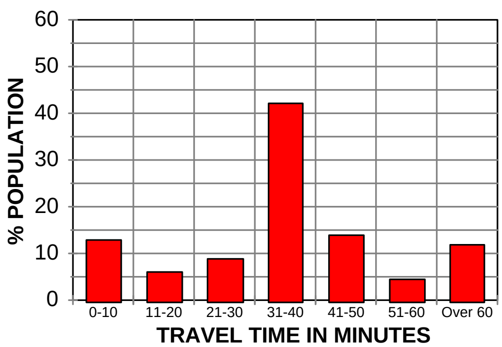
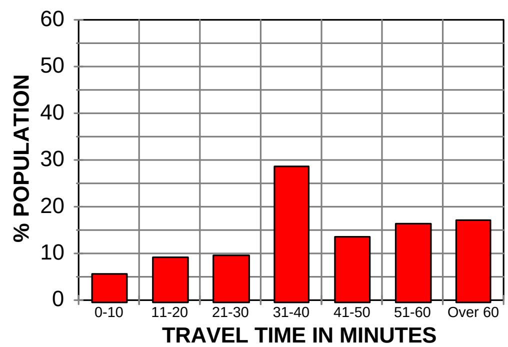


SOUTHWEST



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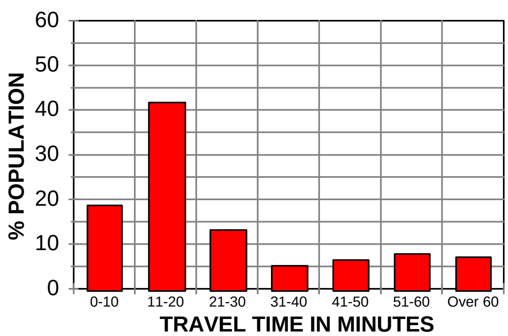
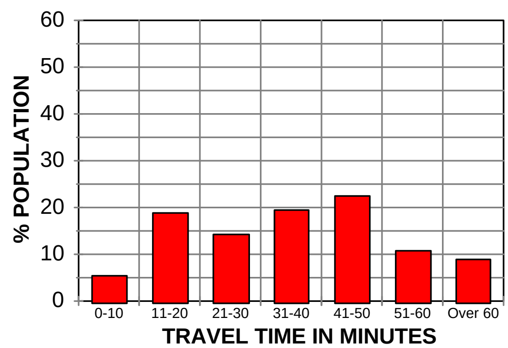


UNIVERSITY



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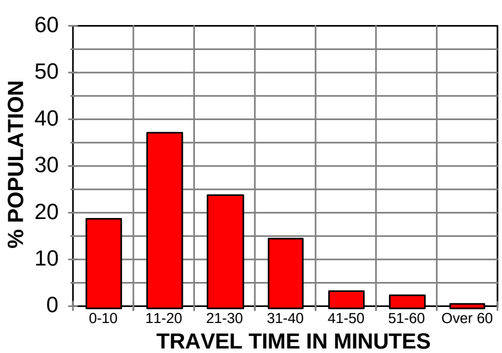
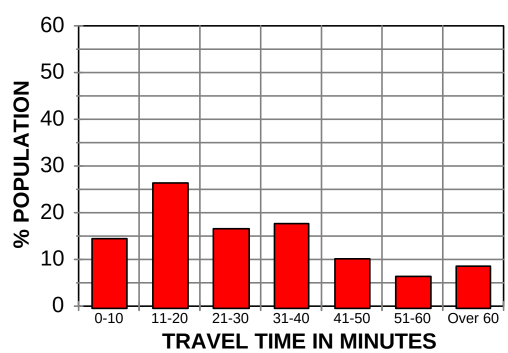
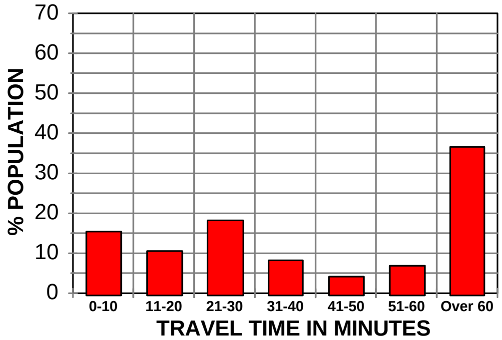


STATEWIDE SUMMARY



Region Summaries: Analysis Group 4 (31 TSCs)
Percent of population served by travel time

SUPERIOR



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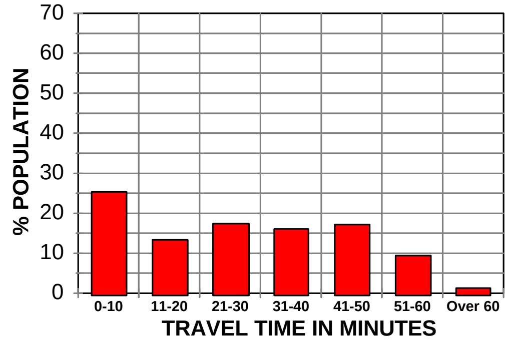

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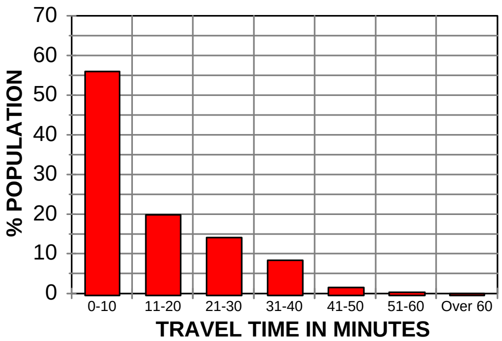

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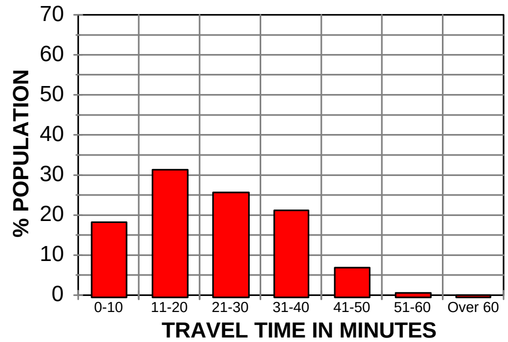

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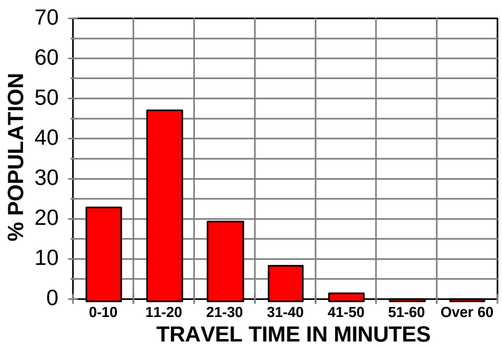

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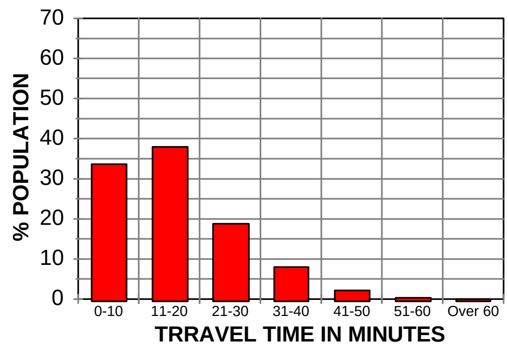

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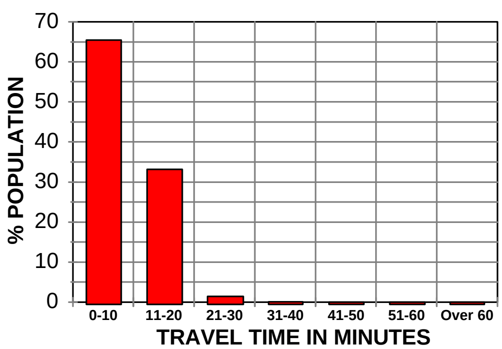

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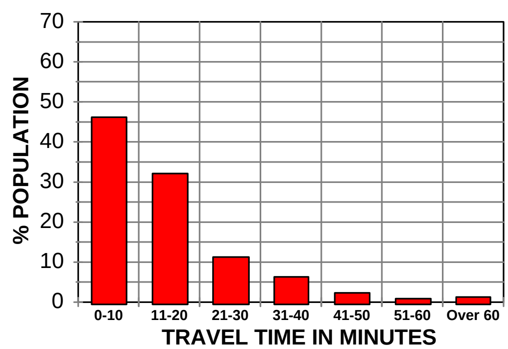

Automated Passenger Counter Pilot Test Project

Michael R. Baltes and Joel R. Rey, University of South Florida

Abstract

For public transit systems to keep pace with the constantly changing travel behavior of the employment and housing sectors in their service areas, improve overall service productivity, justify changes in service, and maintain the highest levels of service quality at the lowest cost, transit system managers/planners need a comprehensive analysis tool that provides accurate, timely, and detailed information about their ridership at various levels of the transit.

Historically, to gather this important information, transit systems have utilized manual ridechecks using transit system staff to count the number boardings and deboardings (alightings) at each stop along a given route. Typically, this method of data collection has not resulted in very accurate nor detailed ridership-level data; nor has it allowed for the accomplishment of this important task at a reasonable cost or allowed for maintaining a current database of ridership at the route and system levels. One possible solution to a transit agency's need for reliable, accurate, detailed, up-to-date, and cost-effectively obtained ridership data is through the use of Automated Passenger Counters or APCs. By utilizing APCs capable of performing the same and additional functions as manual ridechecks, transit agencies can improve the availability of ridership information in the form of boarding and alighting counts at a host of system levels, the accuracy and the amount of data that is collected, and the ease of data transfer and input, while generally realizing an overall reduction in the cost of ridership data collection.

An APC system can be seen as akin to a magnifying glass in that it permits transit managers to intently focus on the productivity and quality of their system's performance at various levels ranging from individual bus stops, route segments, time point segments, and the overall transit system. Just as the development of new technologies such as the computer microchip has increased knowledge about the world around us, an APC system will allow transit managers to identify problems that may not have been possible to identify when analyzing data gathered via manual ridechecks and to create innovative strategies for improving their transit system's performance.

Basically, an APC system provides an automated method for collecting the number of passenger boardings and alightings at a variety of system levels including route, route segment, or specific bus stops by time period and by day of week, for example. Additional parameters that can be measured by an APC system are maximum and minimum load points boarding and alighting rates, dwell times, door cycles, distance traveled and vehicle average speed, for instance.

The objective of the presentation is to describe the findings from an APC pilot test project that CUTR is currently completing for LYNX transit system located in Orlando, Florida (it is anticipated that the preliminary findings from the project will be ready for presentation by May 1997). In this project, CUTR is testing a variety of APC systems (hardware and software) and related technologies (infra-red [I-R] beams, I-R passive array detectors, treadle mat, and low ultrasonic frequencies) from several North American and European APC vendors for possible implementation on a number of different bus types in LYNX's fleet mix including low floor buses and articulates. The APC systems are being tested under normal operating conditions in actual revenue service on a fixed route with heavy ridership. Specifically, the APC systems are being evaluated based on their reliability, functionality, durability, and accuracy as well as their ability to satisfy LYNX's data needs. Ultimately, based on the results from the pilot test, CUTR will recommend to LYNX the final selection of a specific APC system vendor/technology for implementation into their transit system.

Using GPS for Measuring Household Travel in Private Vehicles

David P. Wagner, Battelle; Elaine Murakami, Federal Highway Administration;
and Marc Guindon, LFUCG Division of Planning

Abstract

Personal travel and how it changes is of continuing concern to transportation planners and policy makers. Information about daily travel patterns are generally captured using self-reported information using a written diary and telephone retrieval. This project developed a small, user-friendly, mailable unit including a Global Positioning System (GPS) receiver to capture vehicle-based, daily travel information. The unit is a Sony MagicLink® 2000, a Personal Digital Assistant (PDA) with a backlit screen, weighing about 1.5 lbs. A Garmin® GPS antenna/receiver is attached through the PDA serial port. Finally, a power cord connects the data collection unit to the vehicle electrical system via the vehicle cigarette lighter. The vehicle driver uses a touch-screen menu to enter variables such as trip purpose and vehicle occupancy, but other data such as date, start time, end time, and vehicle position (latitude and longitude) are collected automatically at frequent intervals. Finally, after mail-back return of the units, the data are processed using a geographic information system (GIS) to include calculated results such as travel speed, trip distance, and trip time by road classification and other variables.

This method of data collection has two potential benefits: (1) improving the quality of travel behavior data, and (2) reducing respondent burden, for example, interview time on the telephone for reporting travel. Using GPS technology, while increasing privacy concerns, is expected to improve overall survey responses in travel behavior studies.

The proof-of-concept field test, conducted September through December 1996, placed the units in 100 household vehicles in Lexington, Kentucky. Respondents were asked to use the unit to record personal travel information for six days. Respondents were also asked to participate in a post-usage telephone interview that included a recall interview about travel information for one day of machine usage and also captured information on ease of use and the respondent's attitudes and reactions to this data collection technique. Technical issues related to hardware, software, field implementation, and analysis and comparison of results between self-reported travel and machine-recorded travel are provided.

Personal travel and how it changes is of continuing concern to transportation planners and policy makers. Information about daily travel patterns is generally captured using self-reported information using a written diary and telephone retrieval (or mail-back of diary forms). Problems with these self-reported methods include lack of reporting for short trips, poor data quality on travel start and end times, total trip times, and destination locations. Also, the burden on the respondent may be 20 minutes per person for reporting of one-day (24 hours) of travel, and more than 60 minutes per household using telephone retrieval methods[1].

Nearly 90 percent of person trips in the U.S. are made in a private vehicle. This project combined Global Positioning Satellite (GPS) and Geographic Information Systems (GIS) technology with small hand-held computers (Personal Digital Assistants -PDAs) to capture vehicle-based, daily travel information.[2] The resulting device is a small, user-friendly, mailable unit designed to capture variables that would be entered by the vehicle driver using a touch sensitive menu, such as trip purpose and vehicle occupancy, and to capture automatically-recorded variables such as date,

Figure 1. Lexington Field Test Equipment

start time, end time, and latitude and longitude at frequent intervals. In addition, respondents were mailed an instructional training video to assist with installation and use of the equipment. Finally, after mail-back return of the units, the data are processed to include variables such as travel speed by road classification, trip distance, and trip time. The unit allows for collection of travel data over several days to avoid potential short-term, survey-induced travel behavior changes.

By combining self-reported information with GPS-recorded information, this technology has the potential for both improving the quality of data on travel behavior and reducing respondent burden for reporting this behavior.

Field Test Equipment

The hardware selected for the field test included a Sony MagicLink 2000, a Personal Digital Assistant (PDA) with a backlit screen, weighing about 1.5 lbs (700 gm). A Garmin GPS antenna/ receiver (weight is about .5 lbs (225 gm)) is attached through the PDA serial port. Finally, a power cord connects the machine to the vehicle electrical system via the vehicle cigarette lighter. Figure 1 is a photograph of the test equipment. The vehicle driver uses a touch-screen menu to enter variables such as trip purpose and vehicle occupancy, and other data such as date, start time, end time, and vehicle position (latitude and longitude) are received by the GPS unit and stored in the PCMCIA card in the PDA at frequent intervals.

The user's acceptance of this type of data collection device is key to the future use of this technology for large scale data collection efforts. Ease of use issues were addressed by incorporating a touch screen interface in the device for user input. Operationally, the device mimicked an automatic teller machine (ATM) which is familiar technology to most of the people in the field test. Also, since each household was individually recruited, the data collection unit includes an administration screen so that the menus were personalized to list the names of the individuals in the household. This personalization makes it easy for the driver to select the names of the driver and household members who are in the vehicle.

Components of the software included (1) administration, (2) user interface, and (3) communication between the GPS receiver and the PDA. The administration portion included the screens for entering the individual driver and passenger names, data uploading to a desktop PC, measures of memory availability, and when to "go to sleep" to conserve battery power. The user interface (Figure 2) required the driver to select the vehicle occupants (driver and passengers) and a trip purpose for each trip. Finally, the software stores the GPS data being received by the GPS unit.

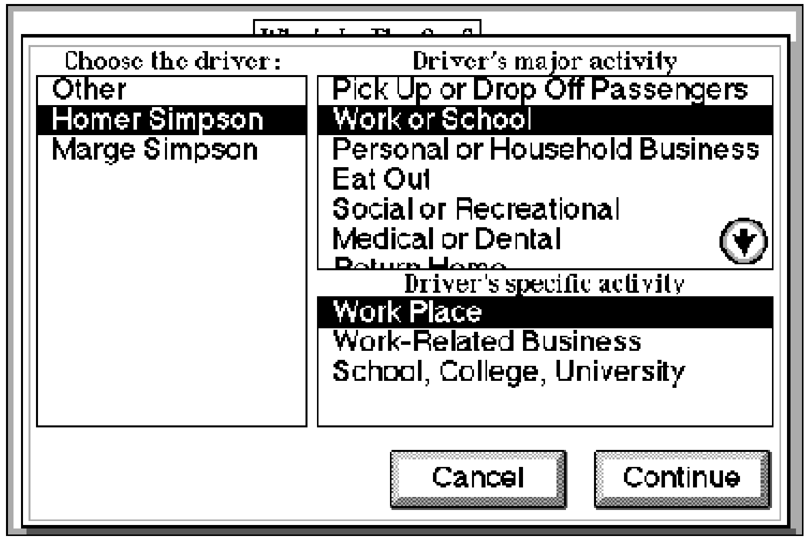

Figure 2: Example of the user interface screens

Field Test Site Selection

The Lexington Metropolitan Planning Organization (MPO) was selected to assist with the field test. The metropolitan planning area of Fayette and Jessamine counties covers 461 square miles with a total population of about 350,000. The MPO was selected based on the willingness of the MPO to provide staff support during the field test, and on the positional accuracy, currency, and completeness of their geographic base file. The street centerline file for Fayette County is positionally accurate within 5-7 feet, and address ranges and street names are updated within 45 days of the changes. Boundaries for Census tracts and block groups are also included on the file.

The field test was conducted in Lexington, KY in fall, 1996, with 100 households. The sample of drivers was stratified by age, gender, and presence of children under age 16 in the household. Respondents were asked to use the machine for six days, with the expectation that data from Day 1 and Day 6 may not be usable. Respondents were also asked to recall all their travel for one 24-hour period (Day 5). This process resulted in a complete 24-hour report of trips made by the selected driver by all modes, and a 4- day report of trips made in the selected vehicle by all drivers and passengers.

Field Test Operations

Recruitment of eligible drivers was more successful than anticipated. The Lexington MPO had arranged for both newspaper and television coverage of the field test shortly before recruiting began. A presolicitation letter from the Lexington MPO, with an enclosed copy of the article from the local newspaper, was sent to approximately 1,300 households with listed telephone numbers. Once the telephone interviewers determined that there was an eligible driver in the household, 67% of those eligible consented to participate in the field test. Their agreement to participate was followed by a mailing including the informed consent papers to read, sign, and return before the equipment would be released for their use. Only two of the households declined to participate after reviewing the informed consent papers.

For the 100 households, the average household size was 2.94 persons, with an average of 2.17 vehicles. The sample of drivers was quite highly educated, with 20 percent completing college, and 20 percent with post-graduate education. The average estimate of annual miles driven was 13,118. This average should be higher than a typical average, because the sample selection process excluded persons who drove less than 3 days per week.

Figure 3 is a general diagram of the activities that took place during the field test. The staff of the Lexington Area Metropolitan Planning Organization had their first training session on the hardware at the end of August 1996. This training session also provided an opportunity for a local TV station to put together some footage for a news spot on the effort, which greatly facilitated the recruitment of volunteer participants.

The survey effort used a total of twenty survey instruments and included 100 households in the Lexington MPO planning area. The survey plan anticipated that the "turn-around time" for each instrument would be an average of nine days for each household.

The first notifications of eligible participants were received by the MPO staff on September 10. The participants were required to complete and sign an Informed Consent form, which discussed responsibility and liabilities, before they could receive a survey instrument. Within the first week, all fifteen available machines were shipped to participants (throughout the first two and a half months of the study, only fifteen survey instruments were available).

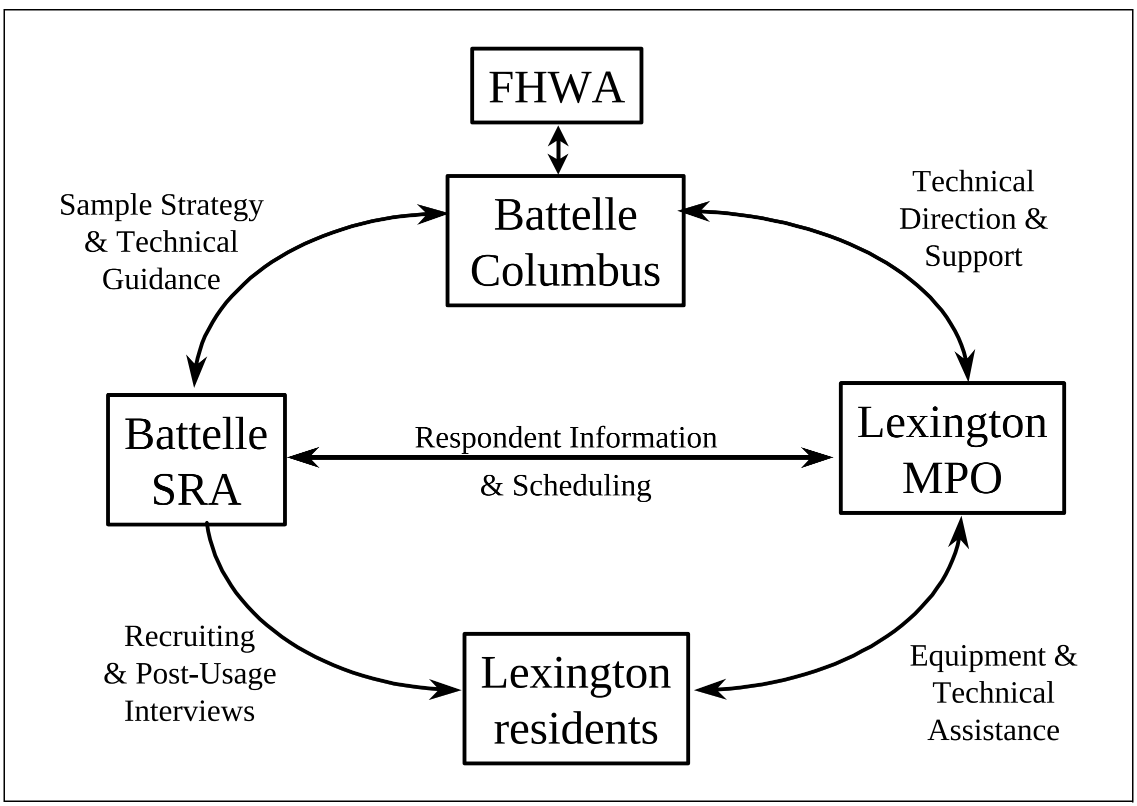

Figure 3: Flowchart depicting general field operations

The Lexington MPO recognized early in the project that organization would be the key to the success of effort. An Administrative Coordinator was assigned to the project and the tasks were divided into two categories: Clerical and Technical. The clerical work included such things as keeping up with the paper work, programming the machines with participant names, and assuring the return of the forms and machines. The technical side dealt with trouble shooting, installation, field assistance and equipment checking. These efforts were conducted concurrently, rather than sequentially, in order to minimize the turn-around time and keep as many machines in the field as possible. The greatest number of machines turned around in one day was seven.

The organization implemented by the MPO allowed the staff to continue their other job responsibilities and the project never consumed more than one quarter of the staff's time.

The tasks undertaken by the Lexington MPO are listed as follows.

- Contacting the Participants,
- Preparing and Sending the Machines,
- Helping the Participants,
- Assuring the Return of the Machines, and
- Receiving and Checking the Machines.

Battelle Survey Research Associates (SRA) was responsible for the recruitment and first contact with the participants. After their selection process was completed, SRA notified the MPO of the names of the participant household. The MPO would then send out an Informed Consent form to the participants. Return of the Informed Consent form by the participants averaged 8.6 days. The minimum turnover time was two days, while the maximum was over three weeks. Delivery of the survey instruments averaged twelve days after receipt of the Informed Consent form. The objective was to ship the survey instruments on the day the Informed Consent form was received, however, after the second or third week a month's backlog of participants were waiting for survey instruments.

When a survey instrument was returned, the data were retrieved and sent to Battelle. The physical condition of the machine, its component parts and connecting wires were checked. Each piece was examined for damage to assure that it would operate in the field again. Some of the software settings were also checked to ensure that they hadn't changed during field use. After checking the physical condition of the equipment, a new PCMCIA card was inserted and programmed for the next participant. Each participant received a survey instrument that was programmed specifically for their household. The settings of the software was checked and the instrument was packaged for shipment. Included in the package was an incentive money order, return shipping instructions (including how and when to return the machine), instructions in both video and written formats and the address of the MPO. A local courier service was contracted to deliver and pick up the instruments.

While the survey instruments were in the field, the MPO staff had several responsibilities. If requested, the staff would install a machine in the participant's car. This happened in only three percent of the cases. The MPO staff also maintained a "hot line" to answer any question or respond to any difficulties that the participants experienced, and would also travel to the participants' homes if they had problems.

Very few problems were experienced with the software or hardware. The most significant problems usually involved discharged batteries, and a battery recharger was generally left with the participant overnight to solve this problem. There were only two occasions where a survey instrument needed to be taken out of the field and returned for repair. These problems were solved quickly and the machines were returned to the field in several days. The survey instruments held up well and none were lost to damage or theft. The public response was enthusiastic and the Lexington MPO staff found the experience to be very positive.

Results

The results of the project include both a post-usage survey and analysis of the collected data. The post- usage survey examined the equipment installation, use of the equipment, and general concerns about the field survey process. Analysis of the collected data characterized the travel behavior of the sample population and compared the machine-recorded data with a "recall" telephone interview for one of the travel days.

Post-Usage Survey

The post-usage survey focused the travel day recall interview on Day 5 of the household's test period. Since the test was designed for six days in each household, Day 5 was expected to be the last full day that the equipment was used by the household. The post-usage interview also included questions about the installation and use of the equipment, general concerns and issues for the households (e.g. privacy), and additional demographic information. Evaluation of the travel recall data is not yet complete. The following results are from the post-usage interviews focusing on evaluation of the equipment and general concerns and issues for the households.

Equipment Installation. Although most people installed the device themselves, women were much more likely to have someone in their household install the GPS device for them. Twenty seven percent (27%) of the women, compared to 10 percent for men, had assistance from someone in their household.

People aged 24 and under were more likely to use the instructional video to learn to install the GPS unit (57 percent compared to about 50 percent for all other age groups). For those who installed the unit themselves, there was no difference by gender in preference between the written manual and the instructional video. Those who used the video for installation guidance rated it higher than those who used the written guide. Eighty-eight percent (88%) of video users, compared to 77 percent of written guide users rated the guide "very clear."

Use of the GPS Equipment. Similar to questions on installation, younger age groups (age 24 and under, and 25-49) were more likely to use the instructional video to learn how to use the equipment compared to older groups. And also, there was no difference by gender between using the written guide or the video for learning to use the equipment.

Over 70 percent rated the device "very easy" to use. The groups which were more likely to rate it "somewhat easy" were: Females 25-49 with children; Women 50-64 and, both Females and Males age 65 and over.

Households with children were hypothesized to be more easily distracted and thus more likely to forget to use the computer each time they got into the vehicle. However, self-reporting on use

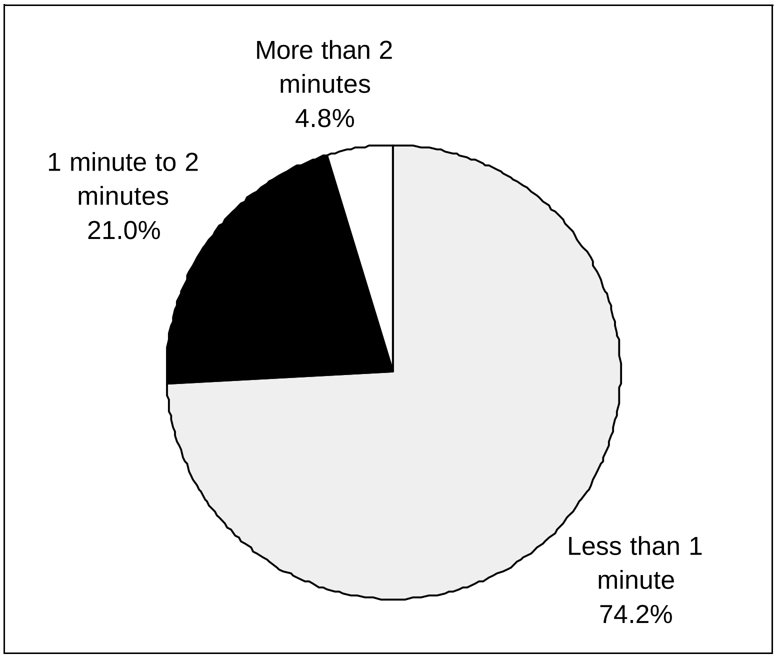

Figure 4: Time required to enter data for one trip

indicates the contrary. Households with children were more likely to report that they used the machine "all of the time." Respondents age 24 and under were the least likely to report that they used the machine "all of the time."

Entering trip data was expected to be easy and require little of the respondent's time once they became familiar with the menu choices. Approximately 74% reported that entering trip information took 1.0 minute or less per trip, and over 95% reported 2 minutes or less (Figure 4).

One of the reasons that the MagicLink PDA was chosen for the field test was because it has a backlit screen and adjustable screen contrast. However, as lighting and glare conditions changed, the contrast setting for the screen needed frequent adjustment to clearly see the screen. Approximately one third of the respondents reported this frequent need to readjust the screen contrast as a problem, making the screen contrast the most frequently reported problem during the field test.

Acceptance of the equipment was also assessed in the interview. The respondents preferred the computer data entry over a written log by almost a 9 to 1 margin, and nearly all indicated that they would use the device again for this type of study. Only one respondent reported changing their driving habits during the field test and that change was reported as omitting a regular, brief stop at a convenience store on the way to work.

General Concerns. Most respondents indicated no concerns about the type of data collected and the government's role in collecting personal travel data. Most of the concerns that were expressed, from about 5% of the respondents, focused on individual privacy concerns. More respondents, approximately 26%, expressed concerns about the safety of their vehicle. These concerns focused on possible break-in and/or theft related to the device. Some respondents reported that they routinely removed the device from their vehicle every evening and reinstalled it in the morning to prevent theft. Others reported other tactics, such as placing a towel over the device to conceal it when they were away from their vehicle.

Data Analysis

Several types of data were generated by the field test for subsequent analysis. These data include participant self-reported information recorded by the hand held computer; GPS records of date, time, and position; travel time and length data derived from matching the GPS data to the GIS map; and recall travel data obtained from the participants during the post-usage interview. The following paragraphs provide some highlights of the analysis results.

Travel Characteristics. The Lexington sample population averaged approximately 4.7 trips per day per household based on their inputs to the hand held computer. Average trip length was approximately 6 miles and average daily travel was 25 to 27 miles. Vehicle occupancy during the field test was approximately 1.6, consistent with national statistics.

Distributions of Lexington sample population travel time and trip length were also compared to 1990 NPTS statistics. These comparisons show that, in general, the Lexington sample population had shorter travel times and shorter trip lengths than the national distribution, for both person trips and person miles of travel (PMT).

Comparison of Machine-recorded and Recall Data. The in-vehicle data collection units were in operation for 5 or 6 days in each vehicle. A "recall" telephone interview with the respondent was conducted on one day during the data collection period. This telephone interview was similar to the travel day portion of the 1995 Nationwide Personal Transportation Survey[3], where information on trips for a 24-hour period is collected.

The comparison of trip start time data is revealing. It is well known that trip start times reported in interviews are often rounded to nearest quarter-hour or half-hour[4]—people simply do not report an accurate trip start time. The Lexington field test equipment recorded these times automatically for each trip initiated by the respondent. Figure 5 shows the frequency distributions of trip start times for the 1995 NPTS 6-month interim dataset, the Lexington data collected automatically during the field test, and the Lexington self-reported (interview) data. The NPTS and self-reported data clearly show peaks at every quarter hour and lesser peaks at every five minute interval. The Lexington data have no such peaks. Trip start times are almost evenly distributed over the entire hour.

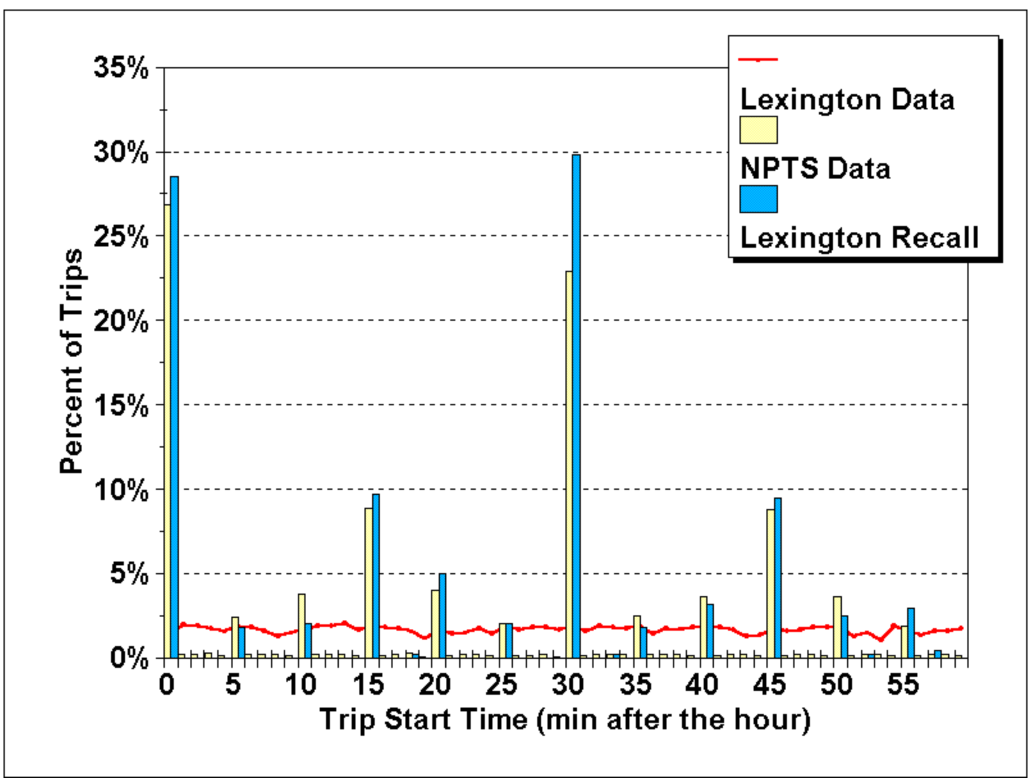

Figure 5: Distributions of trip start times

Conclusions

Combining GPS technology with small hand-held computers is a functional reality, particularly for use in private vehicle surveys. The technology has progressed to the point that small, relatively light-weight, and relatively inexpensive equipment can be delivered to respondents for self-installation and use. Using GPS without additional equipment (gyroscopes, dead-reckoning) is sufficient to plot most trips on the roadway network, even without the availability of differential correction. In addition, matching to the roadway network could be done sufficiently without a positionally accurate geographic base file. That is, map matching is possible, using only the TIGER/Line files available from the U.S. Census Bureau, although errors in some roads would be more likely in areas with parallel roads in close proximity. However, GPS technology alone will not be sufficient to track vehicles in urban canyons and in dense tree cover where the GPS signals may be reflected or obscured.

The touch screen interface was easy to use, even for people over age 65. The general public is responsive to this technology and is willing to participate in multi-day surveys, given a financial incentive.

This proof-of-concept project has shown that computer-assisted self-interviewing (CASI) combined with GPS technology can improve the quality of data from household travel surveys. Because the machine is tracking the start and end times, and the actual routes traveled, the respondent is no longer responsible for reporting similar items. In particular, the reporting of destination addresses is long and time consuming, and often frustrating for the respondent. The frustration may be because the respondent does not know an actual address and may get to their destination using landmarks, or because the telephone interviewer cannot correctly spell or type in the street name.

In addition, the time taken for the respondent to begin each trip using this technology takes about one minute. This is not perceived to be as burdensome as spending 20 minutes on the telephone in one session to report travel of one day.

This CASI approach not only improves the quality of data that is traditionally collected using self-reported methods with paper diaries and telephone or mail-back retrieval, but information which was previously nearly impossible to collect can be collected (Table 1). For example, in the 1990 NPTS conducted on the telephone, one trip of each respondent was selected, and the respondent was asked to estimate how many miles were traveled on what type of roadway (i.e., Interstate, major arterial, collector, local road). Previous efforts to collect this type of information have asked respondents to draw their selected routes on paper maps. Neither of these two methods captures accurate departure time or travel speed. Not only is route choice information easily available by including a GPS component, but because the survey period covers 6 days, variability by day, by day of week, and departure time can be analyzed.

Another objective of this project was reducing missing (unreported) trips. In this project, the respondent was required to turn the equipment on each time they made a trip. If the respondent failed to turn the equipment on (either deliberately or inadvertently), then no trip was recorded, and the data record would contain a gap in the positional information that was recorded. However, when the equipment was on and the respondent made an intermediate stop, the time and positional record will reflect those stops although there is no trip purpose assigned to the activity. Thus the attempt to reduce unreported trips is incomplete. The equipment is currently being modified for a

Table 1: Comparison of traditional telephone survey with GPS/PTS survey

Data Item	Traditional Telephone Survey	GPS/PTS Survey
Trip start and end times	Estimated	Machine recorded
Trip distance	Estimated	Calculable from GPS trace Link distances from GIS
Route choice	Modeled "shortest path"	Actual path from GPS trace
Origin/destination	Recalled street address or intersection	GPS point Address/link match from GIS
Travel speed	Not available	Available from GPS Speed by link from GIS
Functional class	Not available	Available by link from GIS

truck activity survey so that the equipment will turn on automatically when the engine is operating, thus the machine can be designed to collect time and position data, even if the respondent does not actively communicate with the machine.

Acknowledgments

The successful conclusion of this project is a direct result of the active and enthusiastic support of the field test by Mr. Robert Kennedy, Manager of the Lexington Area MPO, the entire MPO staff, and of course, the cooperation and active participation of the citizens of Fayette and Jessamine counties, Kentucky.

User interface software development was performed by FASTLINE, Inc. Key elements of GPS and GIS post-processing and data analysis performed by TransCore (formerly JHK & Associates). Cambridge Systematics, Inc. and Etak, Inc. participated in research planning and the early phases of this research program.

This research program was sponsored by the Office of Highway Information Management and the Office of Technology Application, Federal Highway Administration, U.S. Department of Transportation.

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Reporting and Reducing Non-response in Travel Surveys

Michele Zimowski and Roger Tourangeau, National Opinion Research Center

Abstract

Since the passage of ISTEA and the infusion of resources for data collection, many MPOs have embarked on household travel surveys to replace data collected 15 to 20 (and sometimes 30) years prior. In addition, with the year 2000 approaching, many other MPOs are looking forward to data collection for the new millennium. In current practice, MPOs typically use either transportation planning and engineering firms, or market research firms to collect the data. However, the multitude of firms engaged in this effort has resulted in different methods and different ways of reporting survey results.

This FHWA-sponsored project on survey non-response is part of an effort to standardize reporting practices across travel surveys and to provide practitioners with guidelines for conducting household travel surveys. The project is devoted to establishing a set of best practices for handling non-response in household travel surveys. It focuses on three issues: 1) how to measure and report non-response, 2) how to reduce non- response, and 3) how to weigh and input survey data to adjust for the effects of non-response. An expert review panel of representatives from MPOs and transportation survey firms, and experts in the field of transportation survey methodology, are participating in the collaborative effort to develop guidelines in these areas. The results of this work will be disseminated to practitioners in the field of transportation.

This presentation will summarize the results of this work in the first two areas. The first part of the presentation will focus on best practices for measuring and reporting non-response in household travel surveys. It will discuss such issues as: 1) the appropriate level of measurement — individual or household — for reporting travel survey response rates, 2) establishing criteria for classifying sample members as respondents and non-respondents, 3) the treatment of sample members whose eligibility is unknown, and 4) breaking down the overall response rate into component parts for purposes of evaluating the effectiveness of the field procedures. The second part of the presentation will discuss the relative efficiency and effectiveness of various methods for reducing non-response and address the issues of how to select methods for a particular survey.

The Development and Implementation of a Comprehensive Transportation GIS Network

Tina Roberts and Adiele Nwankwo, Southeast Michigan Council of Governments

Abstract

Geographic Information Systems (GIS) technology is rapidly being introduced into various facets of transportation planning. In many cases, GIS is implemented to address a specific need, which has left agencies with fragmented GIS networks and tools. SEMCOG, the Southeast Michigan Council of Governments, in cooperation with state and local agencies, is addressing this potential problem by working together to create a comprehensive transportation GIS network for planning applications in the region. The objective of this work is to establish a common base containing essential attributes to be utilized by both the state and local agencies.

This paper presents the initial development of the comprehensive transportation GIS network, including the lessons learned in conflating/merging multiple GIS and non-GIS files into a composite regional transportation base, and the strengths and limitation of current technology, such as the problems, challenges and solutions of interfacing between software packages. In addition the challenges of working with multiple agencies that have varied goals and objectives, products and time frames are also presented. Examples of transportation planning applications to date are the developing, updating and displaying of the Tranplan's travel demand forecast results, traffic safety analyses and the use of GIS in intelligent transportation systems operations in transit and general planning applications.

The next step in development and implementation of the GIS network is to make it a more comprehensive system including all roads in the State of Michigan, where initially, efforts focused merely on roads functionally classified as collector and arterial. The comprehensive GIS network will allow for data sharing between agencies by creating common platforms and data transfer standards. Key agencies have come together to create a common base GIS network in the state. This common network will have the demographic information and geocoding capabilities of TIGER, the positional accuracy needed for planning applications from the Michigan Resource Information System (MIRIS) GIS network and a completed Linear Referencing System (LRS) on the remaining roads for the entire state. With this in place, all of the agencies involved, as well as local agencies around the state, will be able to access all data linked to the comprehensive network. Key partners include; Michigan Department of Transportation (MDOT), Michigan State Police, Michigan Department of Natural Resources (MDNR), Secretary of State, Michigan Information Center (MIC), and SEMCOG.

As GIS becomes more of an essential tool in the data input, query, display and analysis of transportation planning, it will become even more important for all agencies to be able to easily share information through a common base. It is anticipated that this project would provide the framework to foster greater coordination and communication among all agencies involved in GIS implementation in Michigan.

Ambassador Bridge/Gateway Project Major Investment Study: The First Application in Michigan

Andrew J. Zeigler, Michigan Department of Transportation;
and Joseph C. Corradino, The Corradino Group

Abstract

Michigan's first Major Investment Study (MIS) focused on access improvements to the Ambassador Bridge. The Ambassador Bridge/Gateway Project represents a public/private cooperative effort. Working with the City of Detroit, community, and private interests, the MDOT and the Southeast Michigan Council of Governments (SEMCOG) have been cosponsoring a planning study to address transportation and related land use needs associated with access improvements to the Ambassador Bridge, linking Detroit, Michigan with Windsor, Ontario. The Ambassador Bridge is privately owned and operated in the United States by The Detroit International Bridge Company (DIBC). This project specifically addresses the need for long-term congestion mitigation and direct access improvements between the Ambassador Bridge and Michigan's State trunkline highways, which include I-96 and I-75 of the Interstate System.

This project is unique for several reasons: (1) it represents a cooperative effort with a privately-owned international bridge; (2) it involves an ethnic neighborhood—Mexicantown—that in addition to a cooperative effort was protected consistent with the Presidents Order on Environmental Justice; and (3) it involved a consortium of state, local and federal agencies and the private sector represented by a Steering Committee that provided guidance throughout the project.

The project included an intense public involvement effort. Public meetings were combined with numerous one-on-one outreach efforts. Alternative access design concepts were progressively developed both in number and scope from illustrative concepts, to practical alternatives, and finally resulting in a preferred alternative. Item after item was debated at the Project Steering Committee meetings, which the public was invited to attend, and did!

The resulting MIS was completed months ahead of schedule; with public support and a community that endorsed the project openly; and a package of $100 million in highway access improvements without displacing any buildings within an urban setting.

The disappointments include the inability to satisfy all the geometric design guidelines and standards ascribed to by the MDOT. The project area was so tight, and the goal of minimal neighborhood impact so important that exceptions to design standards will be required in several places.

The Ambassador Bridge/Gateway MIS is a major success. It is the first approved MIS in Michigan. It demonstrates that cooperation and communication are key to resolving complex issues as part of the MIS process.

In September 1995, the Michigan Department of Transportation (M·DOT), in cooperation with the Southeastern Michigan Council of Governments (SEMCOG), officially initiated the engineering and environmental studies for the Ambassador Bridge/Gateway Project. The studies are required to determine the best alternative to improving access at the United States end of the Ambassador Bridge, which links Detroit, Michigan and Windsor, Canada (Figure 1). The study was guided by a Steering Committee composed of public agency representatives from the Michigan Department of Transportation, SEMCOG, the Federal Highway Administration (FHWA),

Figure 1
PROJECT AREA

and the City of Detroit, with U.S. Customs and the United States General Services Administration acting as federal cooperating agencies. The privately-owned Detroit International Bridge Company (DIBC) was also a member of the Steering Committee. DIBC owns the Ambassador Bridge. Additionally, a citizens involvement group was instrumental in the exchange of information on the project. It included members of local groups, businesses, social service agencies and others rooted in the community.

The project followed a relatively new planning process that allows a narrowing of alternatives through preparation of a Major Investment Study (MIS) (Figure 2). An MIS is now required for major investments of federal transportation funds within areas of the state under the authority of a metropolitan planning organization, of which SEMCOG is one. It is designed to streamline the process leading to project implementation by focusing attention on appropriate decision-making.

The Problem

The problem being addressed by the MIS is the need for improved access at the United States end of the Ambassador Bridge. Access improvements are key to accommodating future border crossing traffic which is growing exponentially and is stimulated by trade among the United States, Canada and Mexico. A brief description of access to the Bridge is important to understanding this project.

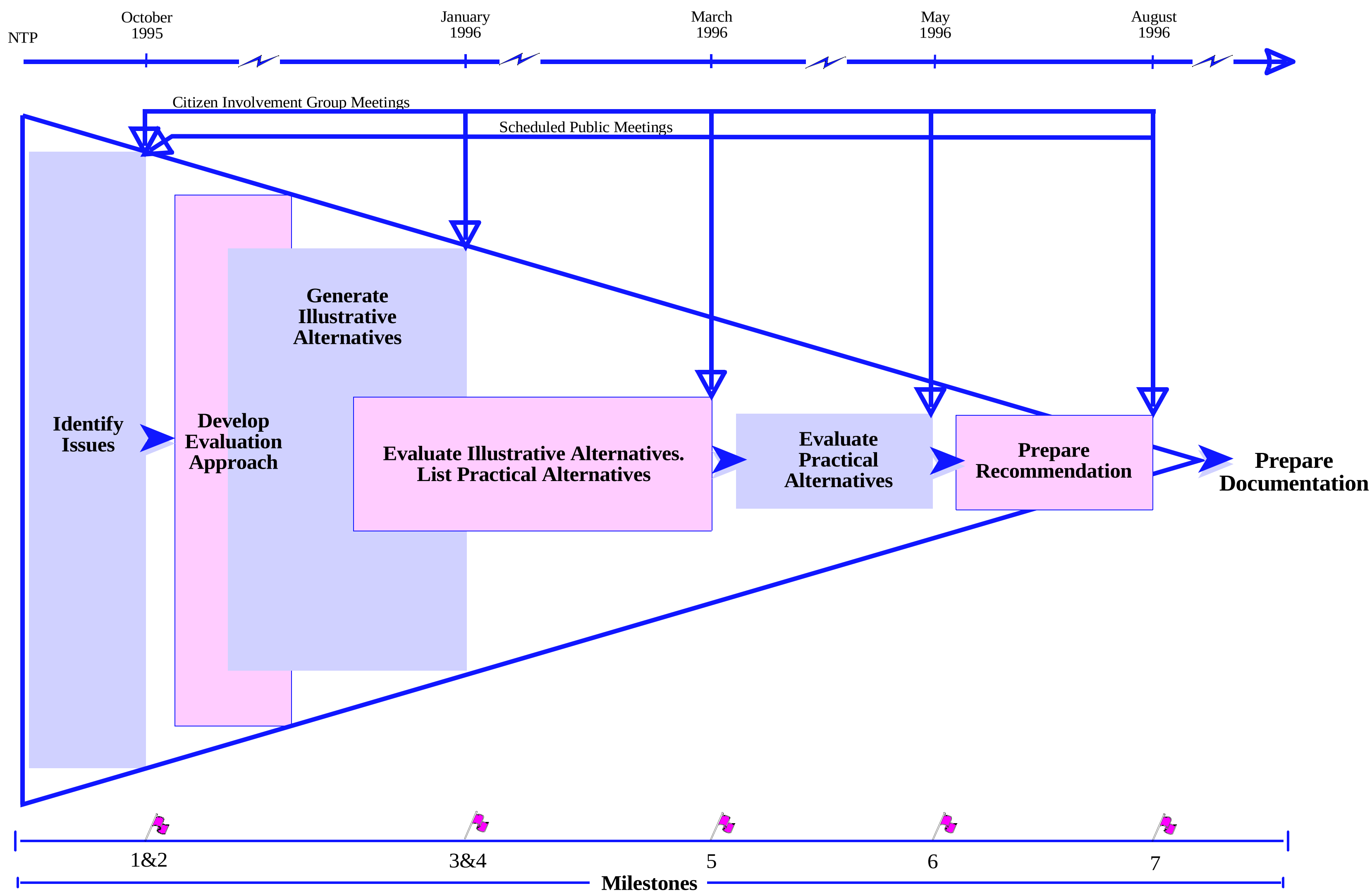
Cars and trucks departing the U.S. get to the Bridge by Michigan's trunkline system using a local street (Porter Street) to get to the Bridge plaza (Figure 3). A toll is paid on the U.S. plaza and the vehicle crosses to Canada, where it passes through Canadian Customs. In the United States, the traveler has the opportunity to buy duty-free (untaxed) goods that can be carried into Canada. This is to occur in a "sterile" area so that officials of the U.S. Customs Services can be assured that no one is purchasing duty-free goods and then staying in the United States.

One may enter the U.S. using the Ambassador Bridge either as an auto or a commercial vehicle. Tolls are first paid in Canada. Then, all vehicles are subject to U.S. Customs inspection. Autos proceed directly north over the bridge plaza then pass through Customs booths. Inspection may be cursory or may require parking in an adjacent area for more thorough inspection. Autos then are confronted with a stop-light controlled, five-way intersection before they can access the freeway system or travel local streets to their destinations.

Commercial vehicles entering the U.S. get into a dedicated lane at the end of the Ambassador Bridge and make a 180-degree turn into a large U.S. Customs facility. There they go through primary inspection and may be subject to rapid release; or, more paperwork may be involved and secondary inspection may follow. Some trucks are returned to Canada via a secured route, if there is some problem with the cargo or its documentation. Otherwise, all trucks depart the U.S. Customs facility onto Fort Street, which is spanned by the Ambassador Bridge. Once on Fort Street, trucks proceed east to Rosa Parks Boulevard or west to Clark Street to access the freeway system.

Affected Area

The project is in the Hubbard-Richard Citizens District and the Mexicantown Commercial District of the City of Detroit. Construction of I-75 split the area and left deep scars on both the physical and sociological fabric of the community (Refer to Figure 1). Along with the overall and significant outmigration of the population of Detroit, the result has been a large amount of vacant land, both on the east and west sides of the freeway. Nevertheless, those who have chosen to



Milestones

1. Kickoff Meetings/Agencies
2. Kickoff Meetings/Public
3. Illustrative Alternatives
4. Scoping Meeting
5. First Evaluation Results
6. Second Evaluation Results
7. Recommended Alternative

Figure 2
MIS PROCESS

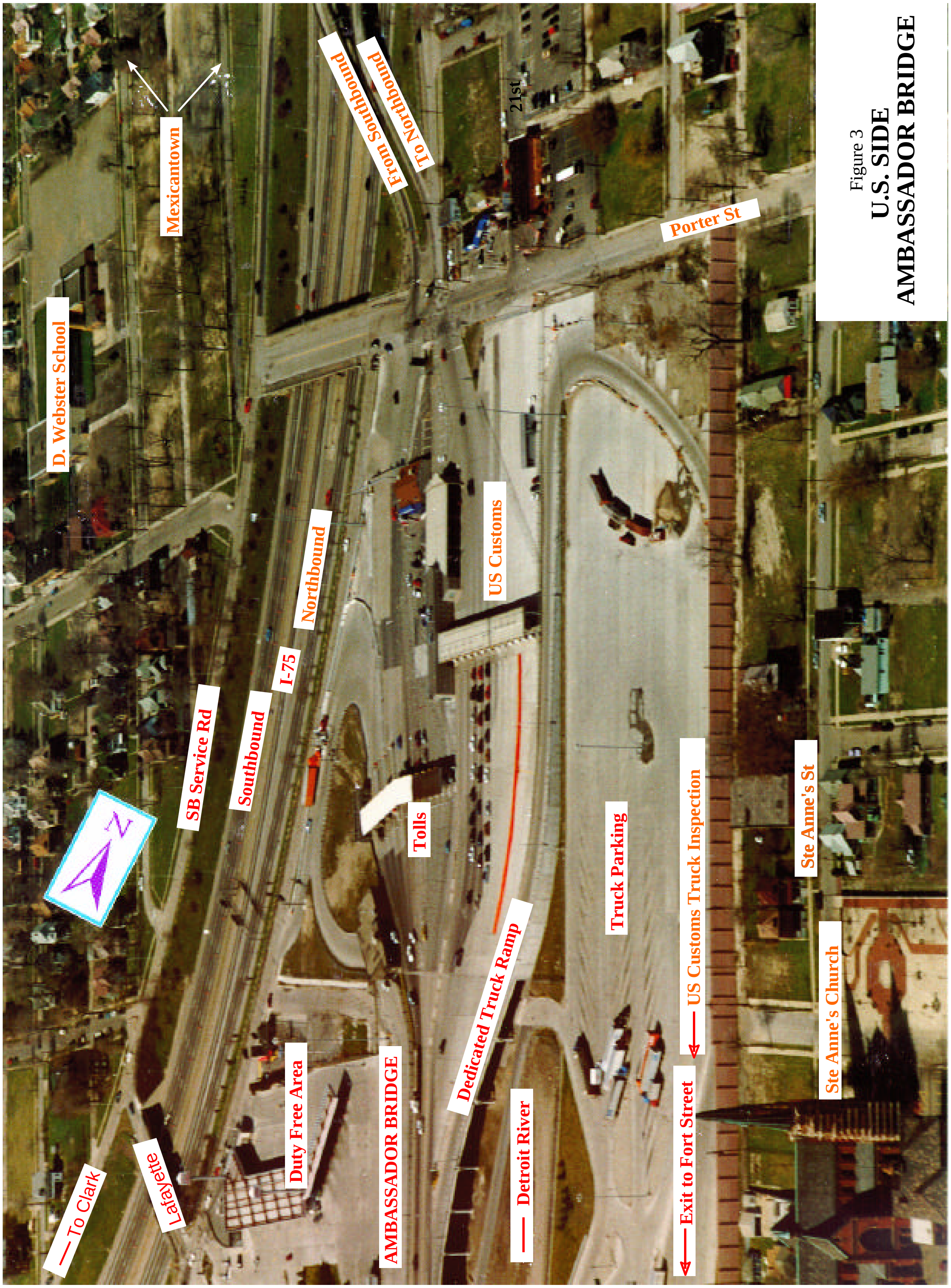


Figure 3
U.S. SIDE
AMBASSADOR BRIDGE

remain are committed to see the area improve. The study area includes a restaurant district fronting on Bagley Street on the east and west sides of I-75.

The BUOY (Businesses United with Officers and Youth) Center, a local center for community activities sponsored by the Detroit Police and local business owners, is also an anchor in the area. Likewise, the Roberto Clemente Community Center located on the east side of the freeway and the Latino Family Services Center located on Fort Street at West Grand Boulevard are major sources of community activity and pride.

The Third Precinct Police Station is located in the northern part of the study area. And, while it is slated for closure and consolidation with another precinct, a police mini-station is likely to remain in the area and could be incorporated into the Gateway Project. Other significant activity centers include the Daniel Webster Elementary School on the west side of the freeway and St. Anne's Church, which is on the National Register of Historic Places, on the east side of I-75.

The Need for Trust

The conditions of the Hubbard-Richard area clearly reflect physical deterioration. Additionally, and, perhaps less visible, is that the process of change has so scarred the community and created mistrust among various factions that, for over 20 years, it has been impossible to advance a solution to the transportation problems at and around the Ambassador Bridge.

Such mistrust greeted the Ambassador Bridge/Gateway Project from the very outset and, only through an extensive public outreach program was it possible to build credibility. This outreach process was fostered by the President's Executive Order 12898 which mandates that environmental justice for minority and low-income populations must be a key part of any federal transportation project.

Clearly, the Hubbard-Richard/Mexicantown community has paid its price over the years in terms of lost housing, disruption of community cohesion, and physical separation of a thriving ethnic enclave. The Ambassador Bridge/Gateway Project was focused at the outset on attempting to minimize any further disruption.

Community Outreach

Numerous meetings were held during the course of the study to solicit information from the public, interested groups and agencies. As noted earlier, the study was guided by a Steering Committee and involved a Community Involvement Group of interested parties. The public was directly involved at all stages with five rounds of meetings held prior to the public hearing (Table 1). Additionally, and more important, dozens of meetings were held with individuals and small groups so that those who had an interest in the project could articulate their concerns in a less-intimidating, more informal setting. A toll-free telephone number was also provided through which anyone could contact the project at any time. An immediate response was then forthcoming.

Another important aspect of the outreach effort was the invitation to all Community Involvement Group members to the Steering Committee meetings. Key community leaders regularly attended. This included the pastor of Ste. Anne's Church and both the President and Director of the Hubbard-Richard Community District Council. Their knowledge of the detailed workings of the project and the players in the neighborhood allowed them to contribute significantly, particularly

Table 1: Meeting Summary

Date	Subject
October 4 and 5, 1995	Public Kickoff Meeting
January 10 and 11, 1996	Presentation/Review of Illustrative Alternatives — MDOT Official Pre-Study Meeting
February 2, 1996	Scoping Meeting for Agencies and Organizations
March 6 and 7, 1996	Evaluation of Illustrative Alternatives
May 8 and 9, 1996	Evaluation of Practical Alternatives/Identification of Refined Alternative
July 9, 1996	Workshop for Refined Alternative
January/February, 1997	Public Hearing

to the final meetings wherein the community's support was gained for going ahead with the project.

Alternatives

Fifteen alternatives were originally considered as well as the Transportation System Management, Mass Transit and Do Nothing options. The preliminary alternatives were displayed publicly in January 1996. No recommendations or evaluations were displayed at that time so that the public could have complete input to shaping and reshaping the options. Subsequently, a scoping meeting was held in February among all agencies and organizations that could be affected by the project. This input then led to meetings in March 1996, which led to evaluation of the 15 options. The public played a role in the evaluation. The alternatives surviving this screening were then reviewed in additional detail, leading to the definition in May of a single alternative with the potential to both minimize impacts and optimize access to the Ambassador Bridge. The preferred alternative was then defined in great detail and computer simulations were presented in a day-long workshop which was held in July 1996 to give the public a clear view of how the alternatives would fit into the community (Figure 4).

A key component of the preferred solution is a pedestrian linkage across I-75/I-96. The community was quite vociferous in its opinion that a link had to re-connect the two sides of the Hubbard-Richard/Mexicantown area. Alternative pedestrian crossing concepts were developed for the public meetings. Each included space for a mini-station to be staffed 24 hours a day by the Detroit Police. This will provide the security necessary to increase the use of the pedway.

Another important physical element in redevelopment of the community is construction of a privately sponsored Travel Information Center/Retail Complex. This facility could represent as much as 80,000 square feet of commercial space to serve the needs of the surrounding community as well as the traveling public. The preferred alternative provides direct access to the Travel Information Center so that its viability is enhanced.

Impacts of The Preferred Alternative

The most significant aspect of this proposed $100 million project is that only one residential unit

Figure 4
FUTURE CONDITIONS AT AMBASSADOR BRIDGE

will be taken by its construction. Additional relocations affect the duty-free operations which must be placed in a “sterile” area consistent with the new design.

The Michigan State Historic Preservation Officer (SHPO) found two districts in the project area to be potentially eligible for listing on the National Register of Historic Places. However, because of the ability to fit the alternative almost entirely within the existing right-of-way, the SHPO found that the project had no adverse affect on these areas. The SHPO further found no adverse affect on two individual properties of historic significance in the area. The project has since been approved by the Advisory Council on Historic Preservation as “reasonable and prudent.”

Other positive effects of the project are increased safety through better access to the Bridge to handle almost twice as much traffic in the next 20 years as is present today; improved air quality, as Bridge traffic is not interrupted by stop lights; and, the enhancement of local access through a pedestrian crossing between the two sides of the Hubbard-Richard/Mexicantown area.

Public Hearing and Subsequent Response

Because of the need to address a number of unique engineering design issues in detail, contact between the public affected, and the Steering Committee, virtually stopped between July 1996 and the public hearing held in February 1997. As a result, the community’s response in February to the preferred alternative was one of confusion. And, a number of entities, particularly commercial interests on the west side of I-75/I-96, as well as both residential and business interests on the east side of the freeways, indicated some opposition to the project. To address this matter, the Steering Committee met on a one-to-one basis with the affected parties to gather more information about their concerns. Alternative concepts that they defined were reviewed in detail and a list of impacts was developed consistent with similar work prepared during the early portion of the project when various alternatives were investigated. As a result of this contact, adjustments were made to the project. These include reconnecting Bagley Street to the service drive on the east side of the freeway (Figure 5); establishing gateways on Fort Street at both 18th and St. Anne’s Streets; and, potential use of ISTEA/NEXTEA “enhancement” funding to improve access to the east side of Hubbard-Richard/Mexicantown. With these adjustments, the community representatives who opposed some aspect of the project were willing to support it.

A Final Note

As a result of the close relationship between the project’s Steering Committee and the community, Michigan’s Governor Engler included it in his State of the State Address as one of only two projects for new construction. This allowed everyone to realize that after over 20 years of frustration, the project had the support of all levels of government because of the willingness of the community to trust and contribute.

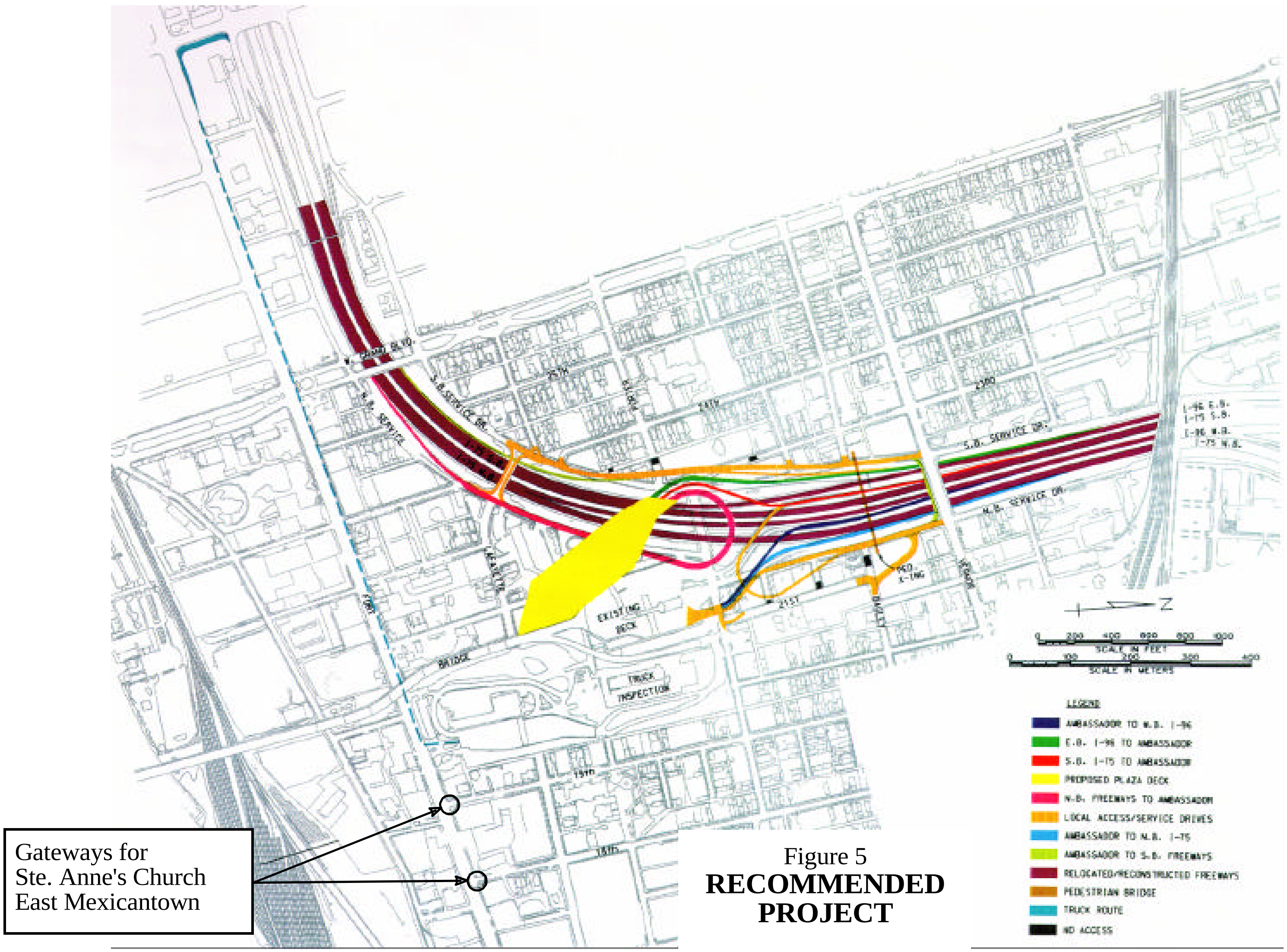


Figure 5
RECOMMENDED PROJECT

Distributing Congestion Management System Information Using the World Wide Web

Jim Gallagher and Seth Asante, Central Transportation Planning Staff

Abstract

The Internet is a unique medium for the distribution of information, and it provides a tremendous opportunity to take advantage of peoples innate interest in transportation issues as they relate to their own lives. In particular, the World Wide Web (WWW), with its ease of use and graphical nature, will allow us to better explain and illustrate transportation ideas and solutions.

To do this, a web site must be interesting, or at least informative. The Boston MPO has WWW site, and the Congestion Management System's First Annual Report is available there. Not simply a document available on-line, the Boston CMS site will attempt to stimulate this interest in the Boston area.

Three goals have been established for the CMS site. The first is to provide another vehicle to encourage public participation. Secondly, it allows people to search for only what interests them, to pursue threads, and to send comments to us. Lastly, it allows us to present background information for people who are interested in more details. This latter goal in particular is a work in progress - information will be made available on-line gradually, as we gain the knowledge and have the resources. The paper would further develop these themes, and the presentation ideally would illustrate these goals through a direct connection with the Boston CMS web site.

This paper briefly summarizes the justification and current state of the Congestion Management System World Wide Web page for the Boston MPO. The Web is being used as part of the larger public participation process of the CMS, but targeting a different audience and providing information in previously impossible ways. While this paper talks about how the site will distribute information, the best way to see and understand its use will be online. At the site (the address is shown below), an interactive version of this paper will be available, showing examples and displaying the evolving nature of the site.

Why the Web for Public Participation?

Public participation in the Congestion Management System has three basic goals:

- To Inform;
- To Interest; and
- To Include.

Public participation will provide the information that we have, ask others to tell us what they know. It will seek to get transportation users, abutters, and residents interested in the transportation issues that affect them, in part by showing that we are interested in their opinion. And it will attempt to include all those who might be affected by the issues under study. The web offers some unique opportunities in each of these areas.

What Information Is Available?

All CMS reports and products will be available online soon after they are published. This will include the CMS Annual Report, the scope of work for all CMS projects, and completed reports and technical memoranda. Meetings notices and agendas, handouts, and meeting minutes or summaries will be available online for all public meetings. Links to additional information at other locations on our site, or relevant sites anywhere on the web, are provided. Besides text and tables, maps and other useful graphics are also presented. All this information will be updated frequently, and some superseded information will be archived.

Why Is This Information Interesting?

With preset internal links, and eventually, a searchable site, the content exceeds simple documents available online. An interactive, customized information tour is developed, focusing only on the information of interest, stored anywhere online. Users can focus on specific locations or topics of interest, follow a problem from identification through alternative analysis and project scheduling, or discover new and unexpected links. The site and its links form one giant database, searchable however the user sees fit.

To accomplish this ideal, information must be current, and outside links must be exhaustive. To date, we have been able to frequently update the CMS site, with new meeting notices and information as it becomes available.

Establishing links to the rest of the net has been more hit-and-miss. Some topics, such as ramp metering, have been the subjects of comprehensive searches because of project needs, but many useful links have not been established. Keeping current is an event more daunting task, although some new search engines will allow us to monitor sites for changes. The resource challenge here will prevent the ideal for the near future.

Nevertheless, it is these links which hold the key to establishing that transportation planning is fun. Someone interested in ramp metering, for example, can use our site not only to find out the cities where ramp metering is in operation, but to visit several of these cities online, and, in the case of Seattle, see actual snapshots of conditions on the ramps just a few minutes ago. Users could then send their comments on the idea for Boston, or ask about future meetings on the subject. While this may not be as interesting as live picture from Mars, it still represents a quantum improvement over traditional fixed-content, text-driven reports.

Who Gets Included?

Certainly, our web site will be used by many who are currently involved in the planning process. Members of the Boston MPO, transportation agency representatives, local officials, consultants, and some members of the public all regularly ask for information that is now available online. For these people, adding links from the information they already access at meetings and through reports would be most important. The availability of additional information online, information traditionally contained in limited-distribution appendices, for example, is another benefit our site can provide.

At least as important from a participation standpoint is the new audience(s) we can reach. Those who can’t easily get out (some of whom might currently have problems accessing our site as well). Those who don’t attend meetings, for scheduling or other reasons. And those who are unaware of our activities but regular users of this new medium. Younger citizens, for example, who traditionally don't take much interest in planning issues, can be reached if we can show them why they should be interested.

We are also hopeful that using the web will extend the number and range of comments. Certainly, commenting will be easy. The potential for anonymity will be attractive to some who might be shy at a public meeting. And, since comments need not be live, using the web allows for deliberation and reasoned responses. Even an exchange of information.

Let's Go Surfin!

Examples of all these capabilities can be seen on our web site. At this point, if you have access, it might be best to visit our site at

www.magnet.state.ma.us/bostonmpo/

Click on Congestion Management System, or simply browse the Boston MPO site. Eventually, we hope to have a tour available to demonstrate the features and uses of our site - it may be online by the time you read this.

Once you have finished with the site, return to this page and we will talk about the future.

What's Next?

This describes where we were with the site as of late May, 1997. The next section of this paper talks about where we plan to go in the future. Some of these extensions may be available on the site by the time these conference proceedings are published.

Virtual Meetings

Notices of public meetings for all CMS studies are posted, along with directions if they are available. Meeting notices for most Boston MPO activities are already published on the web site, representing simply another outlet for making information available.

But the idea of virtual meetings expands this simple concept to include all the information exchanged at public meetings. Tables, charts, and maps given out at meetings, and, in some form, the public presentation itself, can be posted online. Some software applications, for example, allow slide presentations to be saved and played back online as the user wishes. Meeting notes and summaries can also be made available in this way after the meeting. And after any user finishes reviewing this information, he/she can easily submit comments. Anyone who does submit comments can be added to our mailing list and automatically informed of future meetings as well as updated information available online.

This concept of virtual meetings has recently been implemented as part of our Route 20 Corridor Study. In conjunction with a public meeting held June 24, 1997, all of the information discussed above is now available through the Route 20 study portion of the CMS web site.

Linked Maps

Another extension recently implemented is the concept of "linked maps", i.e., linking a map to all the supporting information collected to prepare the map. Normally, if using a map results in requests for additional information, a phone call and searches through databases will be necessary. With linked maps, most of these requests can be answered online.

Recently, another CMS project led to the preparation of a Massachusetts Park-and-Ride map, showing the location of all lots where parking is available for carpool and transit users. This map included some information on available services, phone numbers to call, and directions to the lots.

As implemented online, clicking on a section of the Massachusetts map will provide a more detailed map of lots available in that area. Clicking on a particular lot will then produce a wealth of information about that lot. Besides the name, address, and number of spaces, a locus map showing detailed directions is available. A lot diagram is shown, and pictures of the lot are posted. Where transit routes stop at the lot, the route names, headways, and operator are listed. Some operators have their own web sites, and links are provided - the user can then check the schedule and find out the fare. In the future, when space availability is monitored and posted on VMS signs, links to this information will also be established.

So far, this information is mainly available online only for MassHighway carpool-oriented lots. In the future, we hope to expand the coverage to include the much larger network of transit-oriented lots run by the Massachusetts Bay Transportation Authority (MBTA).

And Further Down the Road?

Project updates

Currently in the Boston MPO, we maintain a database tracking the status of a variety of transportation projects throughout the region. In the CMS, this database is used to determine if locations with identified problems are already on track for solutions. We hope to eventually have this information available online, allowing users to search to see if a project is already planned for their street, town, or area of interest. We cannot yet implement any online database, but we plan to have this capability in the near future.

Chat rooms?

At present, through email, anyone who wants to take the initiative can tell us about current problems or proposed solutions. We may formalize this approach in the future, to allow postings to a “Tell Us About Your Transportation Problems” site, which will include other persons comments as well - in effect, a Boston transportation newsgroup. Eventually, if this generates sufficient interest, we may take this a step further, and set up a Chat Room for an hour or two a week, where people can get feedback on their comments immediately.

Multimedia games??

Between the popularity of games like SimCity with the public and microsimulaion models with transportation professionals, our ability to test scenarios and realistically display the results is evolving rapidly. Already we are using simulation packages to great effect at public meetings to display the results of different alternatives. As soon as the technology to support it is available to us, this too will be available online for individual studies.

Further in the future, users could be able to test alternatives themselves. By tapping into the more detailed knowledge of regular users of an intersection, for example, and combining it with realistic traffic engineering evaluations of alternatives, we could allow citizens to suggest and test solutions. Regardless of whether or not the best solutions emerge from this process, testing alternatives would give users a better understanding of the possibilities and constraints of the planning process. Combine this with budget and resource constraints, projections of future population and employment, open it up to a regional forum online, and we have the public participation process for the TIP of the next century.

What Have We Learned?

Stepping back from this future online transportation planning utopia, what have we learned so far in setting up our web site?

Publicize, Publicize, Publicize

While we are excited about the information available and the improved abilities of our web site, response to date has been disappointing. We have received a few email requests for documents and additional information, but few comments on alternatives or suggestions for improvements. We do not track hits directly, so we cannot tell if people are viewing without commenting.

Some of this lack of interest is undoubtedly the result of an overall lack of interest in transportation planning. As we discussed above, we hope the site can stimulate some interest -- if we can overcome the second problem, the lack of publicity. The CMS paper documents all refer to the site address, and many MPO documents also point to the MPO site. At most public meetings the web site is mentioned. And a brochure explaining the CMS process will soon be widely distributed in all the cities and towns of the region, with the web site prominently mentioned. With time, word should get around to traditional interest groups.

All this publicity utilizes paper avenues. If we are to interest the online community, however, we will have to become known in other ways. Typing in “Boston MPO” or “transportation planning in Boston” into a search engine will find our site, but most of the new audiences we are looking to attract won’t know that this is what they are looking for. What we are trying to do is to establish links to high volume, transportation-oriented sites. For example, the Smartraveler site, which is promoted on TV and radio, provides up to date traffic information for the Boston region. A link on this site could allow people to send comments or complaints about traffic to our site. We are currently investigating establishing such links.

Searchable Site Better than Set Links

Establishing links internal to our site allows us to direct users from problem to study to solution, for example. But it only provides the path and links that we predetermine are appropriate. Users may well want to follow a different path, which they may still be able to do, with difficulty, manually. We cannot currently provide a searchable site, but we plan to have this capability in the near future. At that point we will have both set links and a completely searchable site, which is the ideal.

Need Commitment

Establishing this CMS web site, and the Boston MPO site in general, has been an intensive effort. Converting documents to HTML is an easy task with new software packages, but establishing links requires careful consideration of paths, how many links are appropriate, and how many external links are needed. Converting maps and other graphics to images that are both legible and small enough not to require long download times is another issue that requires some technical expertise. Perhaps most importantly, once online, the site must be kept current, and additional content will likely be added.

CTPS is a large enough agency to have expertise in computers and GIS in addition to transportation planning. Even so, a variety of new skills were needed as we tried to accomplish this work in-house. Several person-months of effort were needed to establish the site, and at least one day a week on average is devoted to keeping the site current. Special projects, such as the online park-and-ride map, can also take many months of resources. The point is, establishing a web site requires a ongoing commitment from any agency, and it must be maintained over several years before its true usefulness can be evaluated.

But...Still Need to Leave the Cave

We believe using the web is an effective way to distribute information and encourage public participation. But it is only one of several methods that must be used to ensure that all citizens have the opportunity to participate. Virtual meetings cannot replace public meetings, only supplement them. Paper copies of reports are still necessary. Phone calls may still be the best way to answer some questions.

Many of us using the web tend to seek all our information online, and it is a very effective way to communicate with like-minded individuals. But not everyone is connected, and the effort to reach these citizens must be just as intense. CMS is leading to more public participation than many transportation professional have been used too. We must not allow use of the web to provide us with one more excuse to sit at our computers, but rather use our site as an information resource while we get out more to the real world.

Next time you’re out, Visit Us at www.magnet.state.ma.us/bostonmpo/ We’re always open!

I-96 Interchange Access Improvement Study: A Look at the Public Involvement Process on an MIS

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Abstract

This Major Investment Study (MIS) is an ongoing study aimed at identifying transportation investments which will best serve the needs of present and future residents in the East Howell area of Livingston County. An integral part of the study centers on the Public Involvement Process. The importance of a productive and inclusive public process is stressed in the guidelines for conducting MIS, and for good reason. With today's scarcity of tax dollars for transportation improvements, it is imperative the public be informed about projects affecting them, and their support obtained before federal, state and local agencies move forward with implementation.

This paper will illustrate to conference participants how the above "vision" for conducting a public involvement process can actually be implemented on a relatively controversial interchange access project. The various techniques and tools used will be discussed including: the development of a formal Public Involvement Plan; the creation of a Community Resource Council; outreach activities designed to draw out "closet" opinions which may have negative consequences if "buried" until late in the study; establishment of a telephone "hotline"...pre-recorded message versus a real live person; as well as stakeholder and citizen focus group interviews. These are all familiar tools and techniques for involving the public, but as we all know, what works well on one project may not on another.

We'll take a look at "Lessons Learned" in terms of what worked well and what didn't work so well. These lessons can then be readily applied to other situations when the controversial subject of improving, removing, or building new interchange access comes up in your city or township…and it probably will!

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