# 1167

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# Transportation Research Record 1167

## Contents

# Foreword

Around the world today, transportation exists on many different levels, from sophisticated multimodal urban systems to rural road networks traveled by foot or oxcart. Each of these different transportation environments offers fresh challenges to the transportation planner. The papers in this Record demonstrate the wide range of transportation planning today.

The first paper, by Robert Bernstein and James Billing, describes an interjurisdictional road improvement implementation plan for Green River Valley in King County, which is south of Seattle, Washington. The plan includes a valley-wide traffic analysis and a financing plan. The second paper, by F. de Corla-Souza et al., describes a process used by the Toledo (Ohio) Metropolitan Area Council of Governments for achieving public involvement in the development of its Year 2010 Transportation Plan. A series of meetings and brainstorming sessions was held to identify issues and needs.

K. Brooks and M. Sung present a description of a demand analysis model that was applied to the Metromover, a downtown people-mover system in Miami, Florida. The model validation process and the model's application for future demand analysis of the Metromover are discussed.

R. S. Timberlake presents a traffic modeling technique. His paper describes how Western-type traffic models have to be altered to take into account the rural and urban environments of developing countries. The paper by G. A. Banjo further discusses the nature of the transportation problems facing developing countries. One of the major negative influences described is the inadequate integration of transportation and urban development actions.

The paper by R. Darbéra is based on a survey of 39 transportation studies done by French consultants in developing countries and the choice of urban transportation planning models that they used. They tended to favor straightforward, unsophisticated models.

H. Moon describes a regression model of development at nonmetropolitan interchanges. The author asserts that the model explains over 50 percent of the variation of the interchange development at 65 nonmetropolitan Kentucky interchanges.

The last paper, by B. H. Immers, focuses on the relationship between small-scale farming and transportation problems. He points out that in developing countries, attention should be given to variety and availability of means of transportation and that agricultural transportation is heavily influenced by the organization of farming.

# Green River Valley Transportation Action Plan: The Development of a Successful Interjurisdictional Road Improvement Implementation Plan

ROBERT BERNSTEIN AND JAMES BILLING

**Rapid suburban population and employment growth accompanied by increasing traffic congestion and general shrinkage of the traditional funding sources for road improvements is a common story across the country. This theme is being played out in south King County, south of Seattle, Washington. To get the road improvement implementation process moving, the Green River Valley Transportation Action Plan (GRVTAP) was developed. GRVTAP is a multijurisdictional implementation and financing plan for road improvement projects in the Green River Valley area. It was developed by the Puget Sound Council of Governments (PSCOG) in cooperation with the cities of Renton, Kent, Auburn, and Tukwila, King County, and the Washington State Department of Transportation (WSDOT). The GRVTAP effort included two steps, a valley-wide traffic analysis and the development of a unified multijurisdictional implementation and financing plan. The main purpose of the traffic analysis was to ensure that the various road improvement projects identified by the participating jurisdictions would work effectively with one another. Development of the implementation plan included a financial analysis to examine the availability of funding from all existing and potential sources. The Action Plan has been adopted by resolution by the councils of each of the participating jurisdictions. GRVTAP has also served as the catalyst for the formation of an organization of private sector interests whose stated purpose is to assist in the funding and implementation of valley road improvements.**

The Green River Valley Transportation Action Plan study area (Figure 1) has been one of the fastest growing parts of the Seattle, Washington, metropolitan area for the last 20 years. Before the mid-1960s, urban development in the Green River Valley, which forms the center of the study area, had been restricted by frequent flooding and ponding during the winter. As a result, the valley had remained largely rural and unincorporated despite its proximity to the highly industrialized Duwamish Valley in Seattle. Agriculture was the dominant form of land use, with truck farms and pasture for dairy cattle predominating. Urban uses were concentrated in the city of Renton along the shore of Lake Washington at the extreme north end of the valley, outside the flood-prone area. After a flood control dam and the first portion of a planned valley-wide drainage system were completed, the cities of Renton, Tukwila, Kent, and Auburn moved quickly to annex most of the unincorporated land and zone a large share of it for employment uses.

Puget Sound Council of Governments, 216 First Avenue South, Seattle, Wash. 98104.

The Green River Valley soon proved to be very attractive to developers. Lying between Seattle and Tacoma, the region offered thousands of acres of level land in large parcels with easy access to the marine port facilities of the ports of Seattle and Tacoma, Seattle-Tacoma International Airport, and two transcontinental rail lines. In contrast, large parcels of undeveloped land were hard to find and much higher priced in Seattle's Duwamish Valley, which is only a few miles to the north. By the early 1970s, two new Boeing plants, the state's biggest shopping center, a number of large distribution facilities, and several business and industrial parks had been constructed on sites scattered throughout the valley. Employment in the region rose from 35,000 in 1965 to 54,000 in 1970.

Although some residential development occurred on the valley floor, employment uses predominated. Home builders were much more active on the plateaus that flank the valley and form the eastern and western borders of the study area. During this period, many single-family and multiple-family residential developments were built in the unincorporated communities of Federal Way and Highline on the west and Soos Creek on the east. The development of the Soos Creek Plateau, in particular, had a large effect on roads in the study area. Because very few jobs were located in Soos Creek, most of its residents had to travel to or through the valley to get to work. This created a pattern of east-west travel across the Green River Valley that continues to be a major factor today.

Both residential and commercial developers benefited from the very active federal, state, and local road-building programs under way at the time. During the late 1960s, Interstate highways were constructed along the west edge of the Green River Valley and across its northern end. The state built one freeway up the middle of the valley and another across its southern end. In 1968 the state launched a $100 million grant program for urban arterials across the state, a measure that was complemented by a voter-approved $80 million county-wide program. Funds from these two programs played an important role in replacing the valley's rural roads with the beginnings of an urban arterial system and in constructing arterials in Highline, Federal Way, and Soos Creek. Property owners also

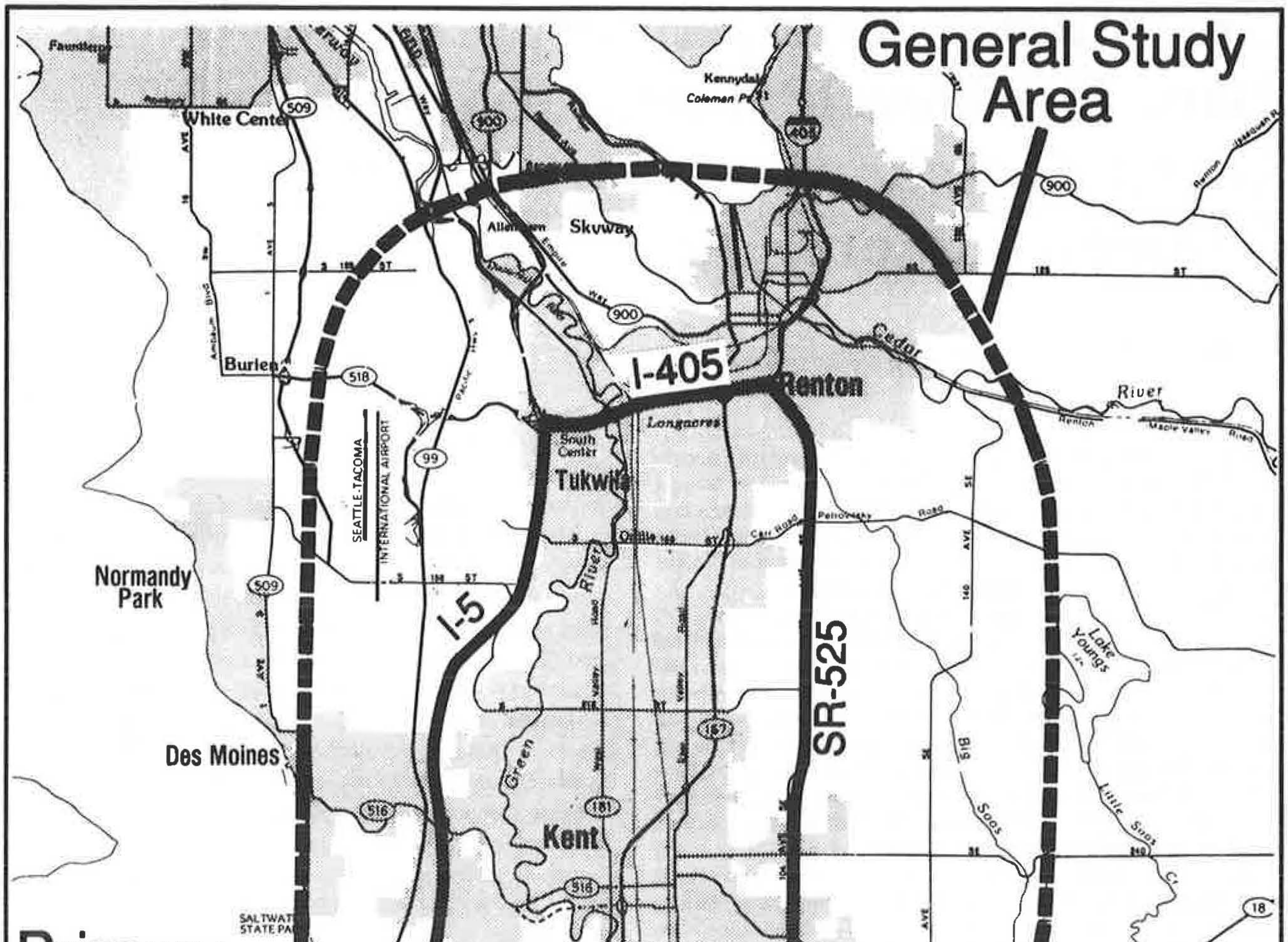


**FIGURE 1 GRVTAP study area.**

provided a share of the funding for many valley arterials through property assessments that were paid to local improvement districts.

The study area's growth rate slowed during the early and mid-1970s. The economy of the Seattle area was hit by a major recession after Boeing, the region's major employer, made big reductions in its work force. At the same time, the region's transportation policies were revised in response to increased environmental concerns and energy shortages. The authors of the new policies expected transit, ridesharing, and transportation system management techniques to meet most of the region's future transportation needs. Road and highway construction, especially in new corridors, was de-emphasized. The combination of the recession, new transportation policies, and competition from other public needs led to a dramatic decline in state and federal funding for projects in the study area and an increased dependence on local sources. This change in the funding picture was to have major consequences during the next phase of the study area's development.

The Seattle area's economy pulled out of its severe recession in 1977, led by improved sales at Boeing and a boom in service jobs. Since then, study area population and employment have been growing rapidly. Thousands of new homes have been built, and millions of square feet of office, warehouse, and retail space have been added. Forecasts indicate that the growth will continue through the end of the century.

Figures 2 and 3 show the 1980 and 2000 distribution of population and employment in the study area. Currently, there are about 385,000 people and some 185,000 jobs in the study area and the surrounding areas. Highline and Federal Way, on the west, account for half the study area population and have the highest densities, but these areas have relatively little vacant land for new residential development. The Soos Creek Plateau, on the other hand, accounts for only about a quarter of the study area population currently but is forecast to receive over half of the population growth because it still has large tracts of vacant land. By the end of the century, the population of the study area and the surrounding areas is expected to reach 480,000, and employment is forecast to grow to 260,000.

Almost two thirds of the employment in the study area is located in the Green River Valley, with most of the remaining jobs located in Highline and Federal Way. In the future, the valley is expected to continue to be the location for most new employment. Employment growth will be particularly heavy in the northern portion of the valley, in and around Tukwila, where employment is forecast to increase from 60,000 to 90,000.

Not surprisingly, the growing number of people and jobs has caused a large increase in traffic volumes and worsening congestion on the road system. This system was not designed to serve the volumes of traffic that exist even today, and its north-south orientation is not capable of serving the growing east-west travel patterns. Ten years ago, I-405, across the north end of the Green River Valley, was the only facility that was consistently congested during peak hours. Today, congestion occurs at many points on arterials and freeways in and around the Green River Valley, sometimes for several hours in the morning and evening. Transit has had some success in attracting commuters headed for high-density destinations, especially downtown Seattle. However, most employment in the study area is located in relatively low-density clusters on sites that are frequently not easy to reach by a transit bus. As a consequence, transit ridership to most points in the study area is low, and the overwhelming majority of workers rely on their own automobiles to travel to and from work.

Despite the increasing congestion and the limited success in attracting the commuters to transit, relatively little has been done to add capacity to the road and freeway network since the early 1970s. The lack of east-west capacity is especially critical. Currently, the state has no plans for improvements in the valley beyond the addition of high-occupancy-vehicle (HOV) lanes on the two Interstate highways. The four valley cities and King County have made plans for improvements, but these jurisdictions have lacked the funding needed to build more than a few major projects. They have also had difficulty coordinating and prioritizing the many planned improvements that involve more than a single valley jurisdiction.

The inability to move beyond the planning phase to implementation and the difficulty that the four valley cities and King County were having in presenting a united front in support of valley transportation improvements caused frustrated citizens, business leaders, and elected officials to call for a new approach. They wanted to integrate existing local plans, identify and prioritize projects of valley-wide concern, develop options for financing them, enhance the valley's collective political clout, and most of all, begin construction of the major projects. This environment gave birth to the Green River Valley Transportation Action Plan.

## GREEN RIVER VALLEY TRANSPORTATION ACTION PLAN

The Green River Valley Transportation Action Plan (GRVTAP) is a multijurisdictional implementation and financing plan for road improvement projects in the Green River Valley. Most of the road improvement projects included in GRVTAP have been identified over the past several years by the various Green River Valley jurisdictions, their consultants, the state, and other ad hoc groups, such as the South King County Roads Task Force.

The GRVTAP was developed by the Puget Sound Council of Governments (PSCOG) in cooperation with the cities of Renton, Kent, Auburn, and Tukwila, King County, and the Washington State Department of Transportation (WSDOT). Plan development was directed by the Valley Transportation Committee (VTC), whose membership includes elected officials and high-level staff from each of the participating jurisdictions and agencies. Policy oversight was also provided by PSCOG's King Subregional Council.

The GRVTAP effort included two steps, a valley-wide traffic analysis, and the development of a unified multijurisdictional implementation and financing plan, or "Action Plan." Numerous transportation studies and analyses focusing on various portions of the valley had been done in the past few years, and there was real antipathy toward the idea of doing "another study." However, no comprehensive analysis of the valley transportation system and all of the proposed road improvements had ever been done. The main purpose of the GRVTAP traffic analysis, then, was to ensure that the various road

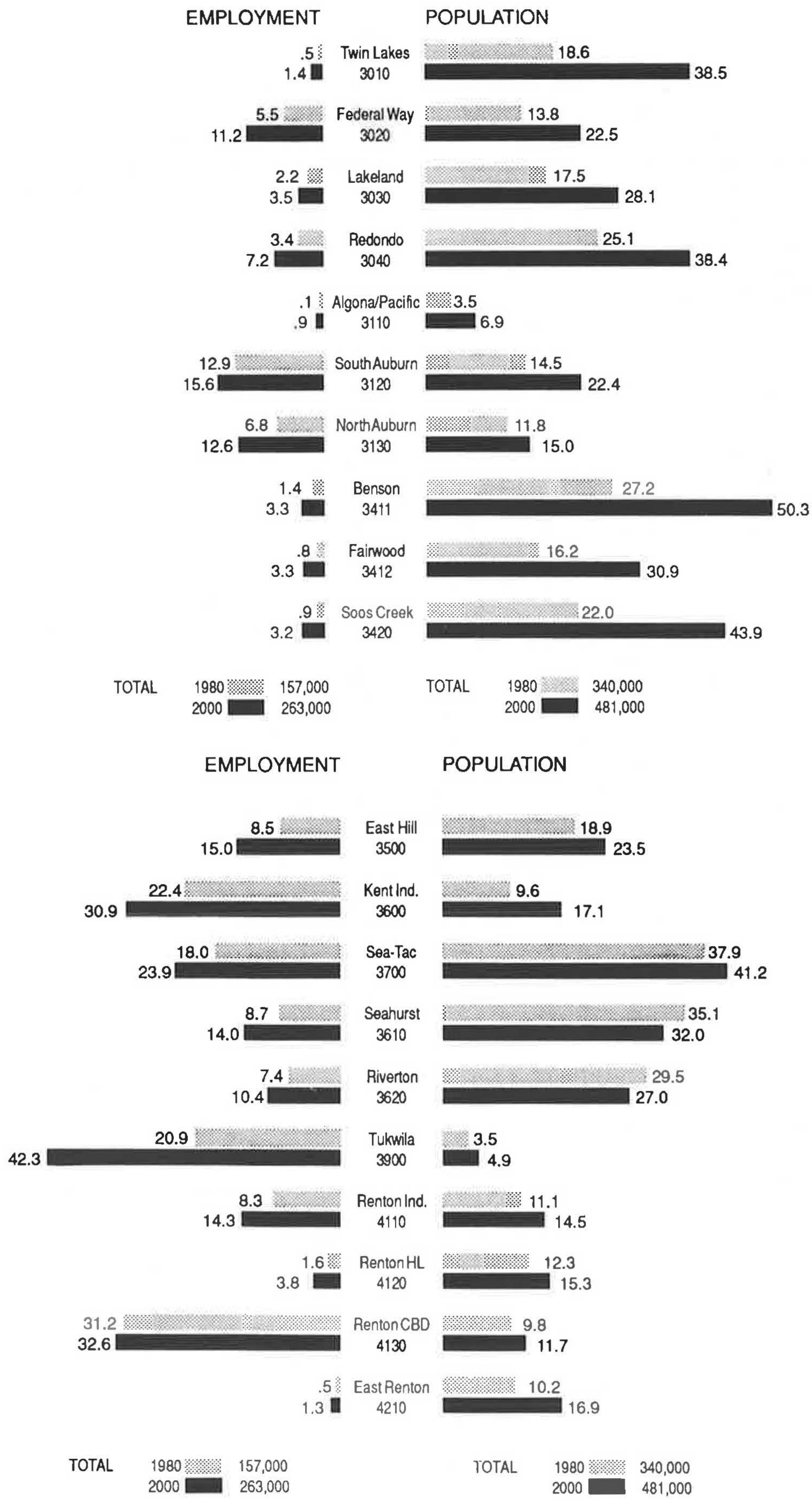


**FIGURE 2 Population and employment (in thousands), 1980–2000.**

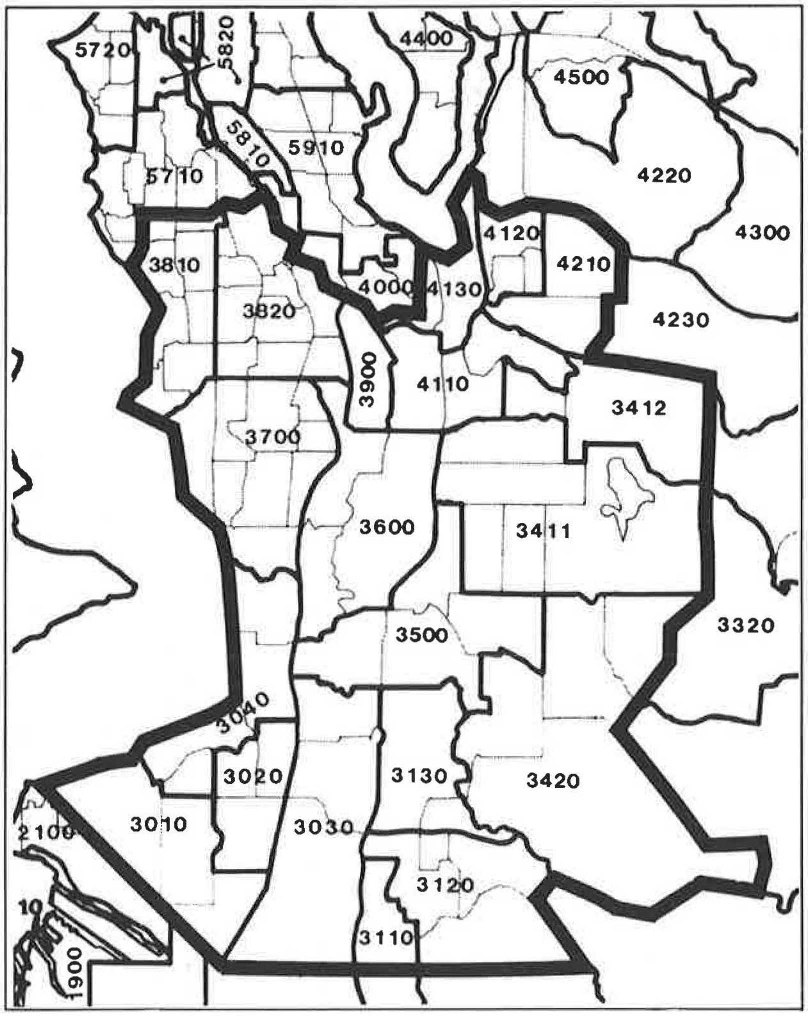


**FIGURE 3 Forecast and analysis zones.**

improvement projects identified by the participating jurisdictions would work effectively with one another.

Development of the implementation and financing plan included a detailed financial analysis, the purpose of which was to identify federal, state, local, public, and private funding sources and to evaluate the potential of each of these sources. A parallel activity was the categorization and prioritization of the identified road improvement projects. Project priorities were compared to funding availability so that funding shortfalls could be identified, and strategies for making up the shortfalls were developed. The project priorities and funding strategies form the Action Plan, which has two main elements, a prioritized program of road improvement projects and a set of recommendations that would expedite the funding and implementation of the projects.

## GRVTAP Traffic Analysis

As the first step of the traffic analysis, VTC identified and agreed upon the alternative sets of road improvements to be analyzed. Important issues to be addressed were also identified. Travel patterns and traffic flows in the study area were evaluated by using PSCOG's regional employment, population, and transportation forecasting models. The traffic analysis resulted in several main conclusions, for which concurrence was obtained from VTC and the King Subregional Council:

- Overall projected traffic flows will virtually flood all major arterials, freeways, and interchanges in and around the valley and on the west side of the Soos Creek Plateau north of Kent;
- The number of freeway interchanges serving north valley employment centers should be maximized to better handle the high proportion and heavy volume of traffic en route to and from the valley;
- All of the proposed cross-valley arterials are needed to carry traffic from the residential areas on the plateau to the employment centers in the valley (even if all are built, they will be overloaded);
- The density of the arterial grid serving the employment centers in the north half of the valley should be maximized (all of the proposed east-west and north-south arterial segments are needed, but even if all are built, there will still be congestion);
- Although the pressure exerted by future traffic volumes will not be as intense in Auburn as in the north half of the valley, all of the Auburn projects will be needed to handle traffic growth;

- To increase the passenger-carrying capacity of the valley road system, HOV improvements should be considered in the planning and design of all valley road projects; and
- Solutions to future traffic and transportation problems must be sought in land use management, as well as in road construction and in management of the transportation system.

## GRVTAP Project Prioritization

Each of the recommendations in the Action Plan relates directly or indirectly to all or part of a program of road improvement projects identified by the five Green River Valley jurisdictions through VTC. After compiling the list of projects and cost estimates for each, VTC prioritized the list. Projects were first grouped into two categories: those of valley-wide importance and those of localized impact and importance. The VTC then prioritized the projects of valley-wide importance (i.e., the "Valley Program") by determining which projects were highest priority, which were high priority, and which were "other" priority. Each jurisdiction prioritized its own local projects by using the same three priority levels. Total costs for the projects in each of the priority categories are summarized in Table 1.

TABLE 1 SUMMARY OF COST ESTIMATES

| | Cost ($ millions) |
|---|---|
| Valley Program | |
| Highest priority projects | 163.9 |
| High priority projects | 112.4 |
| Other projects | 31.5 |
| Total | 307.8 |
| Local Projects | |
| King County | 6.6 |
| Kent | 5.1 |
| Renton | 13.3 |
| Auburn | 35.8 |
| Tukwila | 18.7 |
| Total | 79.5 |

After reviewing the financial analysis (next section), the VTC identified a list of extraordinary projects, so-called because these are priority projects whose implementation will require extraordinary interjurisdictional cooperation and extraordinary funding sources. The extraordinary projects are listed in Table 2. Table 2 also contains an initial estimate of the availability of public funds for each extraordinary project, as well as estimates of the private sector contributions that could be obtained given current local funding strategies.

## GRVTAP Financial Analysis

The implementation of the projects recommended in the Green River Valley Transportation Action Plan is dependent on the availability of adequate funding. Although other obstacles must also be overcome, the lack of funds has been the primary impediment to the implementation of the more costly of the Action Plan projects. The financial analysis identified potential funding sources for the participating local governments, assessed the amount of funding potentially available from each during the implementation period (1987–2000), and provided a set of conclusions that served as the basis for the recommendations adopted by the VTC, the participating jurisdictions, and the King Subregional Council.

Four categories of funding sources—federal programs, state programs, city and county sources, and study area sources—were identified and assessed. The first two are sources of external funding, which traditionally have played important roles in funding projects in the study area. The last two are sources that are controlled by the local jurisdictions.

The federal programs most applicable to the Action Plan projects are the Federal Aid Urban System, Bridge Replacement, and Federal Aid Safety programs. The federal role in financing local projects has been declining and will probably continue to decline gradually, but grants from these three programs are expected to continue to be available. Federal grants for Action Plan projects should total between $15 and $20 million during the implementation period. Because of the nature of the prioritization systems used to award grants from these programs, the funds will probably be distributed among a large number of projects. Relatively little federal money will be available for the extraordinary projects.

The state's urban arterial program has been one of the most important sources of grants for projects in the study area during the last 20 years, but it is rapidly running out of funds. Other state programs have limited applicability to the Action Plan projects. The most promising of the other programs is the Public Works Trust, which makes low-interest loans for infrastructure improvements, including transportation. However, the loans are limited to no more than $1 million for any single project; hence they cannot be expected to fund the extraordinary projects.

The state also shares a large portion of the gasoline tax with city and county governments. This is the most important single source of external funding, but because it is distributed monthly on a formula basis, it cannot be considered a major source of funding for the extraordinary projects. Instead, the valley cities are expected to use about half the $24.7 million that they will receive over the implementation period for maintenance and operations. The remainder will be used primarily to fund many of the smaller capital projects. King County is expected to use the $144.6 million that it will receive from the gasoline tax for maintenance and capital projects throughout the county, including the Action Plan area.

As the Action Plan was being developed, discussions were beginning in the state legislature on a possible increase in the motor fuel tax, new grant programs for local transportation projects, and a new form of special district—the "transportation benefit district"—to give local governments additional flexibility in making transportation improvements. The major purpose of the proposed new grant programs and the transportation benefit district was to support economic development with needed transportation improvements. The Action Plan noted that if the gasoline tax and new grant programs were approved, the prospects for receiving state funding for some of the extraordinary projects would increase dramatically. Passage of the transportation benefit district legislation would allow of needed improvements. They would prefer to see the funding burden shared by the state, the jurisdiction, all properties benefited, and developers. VATA intends to work hard during the next session of the state legislature to pass a gasoline tax increase that will provide substantial funding for Action Plan projects.

## CONCLUSIONS

In many ways, the Green River Valley Transportation Action Plan broke no new ground. It did not identify any previously unidentified road improvement projects, and it did not uncover or develop any new sources of funding. In short, it offered no miracle cure for traffic congestion or funding problems. In fact, some might consider the total valley-wide funding requirements and shortfalls—compiled for the first time by GRVTAP—to be downright demoralizing. However, the Green River Valley Transportation Action Plan may be a catalytic effort that appeared at exactly the right time and place. Traffic congestion in fast-growing suburban areas like the Green River Valley is receiving increasing recognition as a serious threat to the economic well-being of the Seattle area and to the political careers of local and state elected officials. The Action Plan has provided a rallying point for the political and business leadership in the valley. It has shown them that they can agree among themselves on the projects that need to be undertaken and that a large share of the projects can be funded, provided that they are willing to make some hard decisions locally and that the state provides additional funding. Finally, it has given these leaders a unified, credible plan of action to take to the state legislature and their voters.

## ACKNOWLEDGMENTS

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### Recommended Actions: Project-Related

First, local jurisdictions should work with WSDOT and PSCOG to have the proposed new freeway interchanges and interchange improvements put into the state's plan and funded. Second, because little of the nearly $30 million shortfall in funding for interchange projects is likely to be made up through federal and state grants or local general taxes, efforts should be made to make up as much of the shortfall as possible with revenues raised from the properties within the valley. Third, because the GRVTAP traffic analysis indicates that a higher private share can be justified, Kent should consider the feasibility of increasing the share of costs borne by the private sector for the cross-valley arterials in Kent. Also, King County should consider methods for augmenting mitigation payments with additional private contributions for its segments of these corridors. Fourth, even with additional mitigation-derived private sector contributions, there will still be some significant funding shortfalls for Green River Valley projects. For this reason, consideration should be given to expanding the private role to include all properties, including those that are already developed. Possible techniques include city bond issues, formation of area-wide improvement districts, and the creation of a road service district or a transportation benefit district, that is, an RSD/TBD (if the TBD is approved by the legislature), for the Green River Valley as a whole.

Fifth, the use of city bond issues should be considered for funding valley program projects that are not physically in the valley. Bond funds should also be considered for supplementing private sector funds obtained through mitigation payments or through a Green River Valley RSD/TBD. Sixth, area-wide improvement districts, such as local improvement districts (LIDs), should be considered if a Green River Valley RSD/TBD is not created. Finally, because the segments of the southernmost cross-valley corridor east of the Green River are expensive and not well-suited to the private funding mechanisms discussed for the valley, consideration should be given to making them the top priorities of the valley jurisdictions (as a united group) for MAP and for King County 2000, in the event that either of those programs is created. Consideration should also be given to including areas adjacent to such segments in a Green River Valley RSD/TBD.

## PROSPECTS FOR THE FUTURE

The Green River Valley Transportation Action Plan was completed in January 1987. During the following month, the Action Plan was endorsed by the councils of the cities of Renton, Tukwila, Kent, and Auburn, King County, and the King Subregional Council of the Puget Sound Council of Governments. WSDOT reviewed the projects recommended for the state system but asked that additional analysis of their impact on freeway traffic operations be conducted before the projects are added to the state transportation plan. Work on the requested "South King County Freeway Operations Study" began August 1987.

The Action Plan jurisdictions are anxious to start the extraordinary projects but continue to be hampered by a lack of funding. The state, for its part, also lacks the funds needed to make the improvements to the state system that were recommended in the Action Plan. Nonetheless, the Action Plan has already had a number of positive effects.

With luck and perserverance, there is now a good chance that a large share of the Action Plan projects will be completed during the implementation period (i.e., by 2000). For example, although the proposed increase in the state gasoline tax failed during the last legislative session, conversations with state legislators indicated that there was a growing awareness of the need to provide funding for improvements in rapidly growing areas like the Green River Valley. The gasoline tax that failed would have created a new grant program for "multiagency arterial projects," with $30–$40 million in annual funding for at least the next 4 years. Most of the Action Plan's extraordinary projects probably would have been eligible for funding by this new program.

The proposed gasoline tax increase also included a statewide list of specific projects that would have been funded if the gasoline tax had passed. The S-272/277 corridor, one of the three proposed cross-valley projects included in the Action Plan as an extraordinary project, was among those on the list. Also included on the list, but just outside the Action Plan area, were the completion of two state freeways and the construction of a very expensive new bridge on a major arterial. Although the three projects were outside the Action Plan area, they would have had a positive effect on its transportation system.

The state legislature did approve the creation of transportation benefit districts. The Action Plan jurisdictions can now form one or more districts for the purpose of implementing the Action Plan projects. The districts can fund projects by forming assessment districts, charging a fee to mitigate the impact of development on the transportation system, and asking voters within the district to approve tax-supported bonds and tax levies. However, the legislature did not approve a grant program to provide state funds to match those raised by the transportation benefit districts.

At the local level, the King County executive announced his strong support for the Action Plan. The county intends to examine its capital improvement program to see if the timing of the extraordinary projects can be advanced. The voters of Auburn approved a bond issue to pay for their share of the S-272/277 corridor project and other arterial improvements. Kent's mayor and council have also indicated support for moving ahead quickly with the Action Plan projects, especially S-272/277. The city is considering the potential for forming a transportation benefit district or proposing a city-wide bond issue. Tukwila has hired a consultant to detail the options available for financing their projects. Renton's officials are continuing to implement their mitigation payment system, which they expect to use as the source of much of the funding for their share of the extraordinary projects.

The involvement of the private sector has increased since the completion of the Action Plan. The Valley Area Transportation Alliance (VATA) was formed by a broad coalition of businesses with interests in the valley. Their purposes include working for the implementation of the Action Plan projects and ensuring that a fair and equitable approach to funding the projects is developed. In particular, the VATA members question the use of mitigation payments for more than a limited share of the cost obtain permits, property owners have been required to pay the entire cost of improvements that primarily will benefit their projects and to contribute to the cost of off-site improvements that will benefit other developments and the general public. The contributions generally take the form of a cash payment, which goes into a pool of funds, or an agreement not to protest the formation of an assessment district to accomplish the necessary mitigation improvements.

The conditioning of development permits on mitigation payments has been under way for only a couple of years, but it is already controversial. However, the lack of funds from external and local sources has caused the Action Plan jurisdictions to increasingly consider the developers as a source of funding for transportation improvements needed to accommodate growth. The share of funding that the developers are expected to provide varies from jurisdiction to jurisdiction and from project to project, but for some major projects it is as high as 90 percent. The large share that is being sought from developers reflects the scarcity of funds available from external sources and local taxes and bonds. As the Action Plan was being developed, this source was the main one available for funding the extraordinary projects.

Several major conclusions can be drawn from the financial analysis. Federal grants can be expected to fund a portion of a number of the smaller Action Plan projects but will fund only a very small share of the cost of the extraordinary projects. Without new legislation, state grants and loans are likely to fund only a few of the Action Plan projects and only a very small share of the cost of the extraordinary projects.

The state legislature is considering an increase in the gasoline tax to fund new grant programs that would be especially focused on rapidly growing employment areas. If the legislation is passed, it would greatly increase the chance for funding some of the extraordinary projects. It is possible that state approval of the transportation benefit district legislation could also give the Action Plan jurisdictions, property owners, and citizens within the Action Plan area a potent new tool for funding the extraordinary projects.

In summary, existing external sources will be able to fund more than a small fraction of the extraordinary projects. An increase in the state gasoline tax, accompanied by new grant programs focused on the needs of areas like the Green River Valley, offer the most hope for providing external funds for the extraordinary projects.

Local taxes and bond issues are unlikely to provide a significant portion of the funding for the Action Plan projects. However, the Action Plan jurisdictions do have the capacity to fund a number of the extraordinary projects with voter-approved bonds if they choose. A minimum vote of 60 percent in favor would be required, and the bond proceeds would not be available for other competing public needs. The use of a bond issue sponsored by an Action Plan transportation benefit area may be a more appropriate means of obtaining bond funding for the extraordinary projects.

Property owners within the Action Plan area are currently being expected to make up the shortage of funding for the extraordinary projects. The availability of property owner contributions rests primarily on the ability of local governments to condition approval of development permits on the mitigation of transportation impacts. Although local jurisdictions expect to fund up to 90 percent of the cost of the extraordinary projects with mitigation fees, their long-term prospects are uncertain, both legally and politically.

The Action Plan area jurisdictions must seek new tools like the transportation benefit district and new state grant program as a means of broadening the funding base for the extraordinary projects.

## RESULTS

The following recommendations were developed and endorsed by the Valley Transportation Committee as a whole. The recommendations fall into three main categories: (a) general recommendations, (b) recommended actions related to the legislative process, and (c) recommended actions related to specific projects and groups of projects. The recommendations listed below were intended to suggest a range of potential approaches and solutions to a range of technical and financial needs and problems.

### General Recommendations

First, King County and the cities of Kent, Renton, Auburn, and Tukwila should endorse GRVTAP, its project priority lists, and its traffic and financial findings and conclusions. Second, a "marketing strategy" aimed at publicizing, selling, and implementing the GRVTAP recommendations should be developed and put into action. Third, a permanent committee should be created to coordinate the planning, financing, and construction of valley transportation projects and to lobby for needed legislative changes. Because of the increasing dependence on private sector funding for transportation improvements, this group should include private sector representatives. Fourth, PSCOG and WSDOT should undertake a freeway operations study that will evaluate the ability of the freeway system and its interchanges to accommodate future traffic demand and will determine the operational feasibility of the various interchange improvement projects included in the GRVTAP. Finally, to maximize the passenger-carrying capacity of the road system, an assessment of the potential for HOV facilities should be included in the planning and design of all GRVTAP projects.

### Recommended Actions: Legislative

First, an increase in the State Motor Fuel Tax should be supported. Next, creation of a Multiagency Arterial Program (MAP) should be supported. The extraordinary projects would be used as the Green River Valley's list of MAP projects, and the legislature should be made aware of the need for funding for these projects. Third, the proposed transportation benefit district legislation and the creation of a transportation benefit district program funded by the motor fuel tax should be supported. Fourth, the designation of one of the cross-valley corridor projects as a state highway should be sought, as should state funding of construction. Fifth, if the "King County 2000" initiative (a regional capital improvement needs list developed by civic leaders) includes a proposal for a county-wide transportation bond issue, inclusion of the extraordinary projects among the projects to be funded should be ensured.

**TABLE 2 EXTRAORDINARY PROJECTS: ESTIMATED COST, FUNDING AVAILABILITY, AND SHORTFALL THROUGH 2000**

| | PROJECT | Estimate of Funding Shortfall ($ million): high (project cost) | min | Estimate of Available Agency Funding: Public | Private |
|---|---|---|---|---|---|
| | 192/196 CORRIDOR | | | | |
| King | S 192/196, SR-515 - 140 SE | $4.1 | $1.0 | 50% | 25% |
| King | S 192/196, SR-167 - SR-515 | $4.9 | $2.5 | 25% | 25% |
| Kent | S 192/196, W Valley - SR-167 | $19.3 | $7.7 | 10% | 50% |
| Kent | S 196/200, Orillia - W Valley | $4.0 | $1.6 | 10% | 50% |
| Kent | S 200 Connector, Orillia - I-5 | $3.0 | $2.3 | 0% | 25% |
| WSDOT | I-5/S 200 Conn/SR-509 interchange | [not available] | | | |
| | 277 CORRIDOR | | | | |
| King | SE 277, SR-167 - Auburn Wy N | $3.1 | $2.3 | 10% | 15% |
| Auburn | SE 277, Auburn Wy N - Green River | $3.2 | $1.4 | 30% | 25% |
| King | SE 277 Ext, Green River - SR-18 | $14.3 | $10.7 | 10% | 15% |
| Kent | SE 277 Ext, Green River - SR-516 | $8.5 | $3.4 | 10% | 50% |
| WSDOT | SR-18/SE 277 Ext interchange | [not available] | | | |
| | W VALLEY/180 INTERSECTION | | | | |
| Kent | W Valley/S 180 | $0.6 | $0.2 | 10% | 50% |
| Tukwila | W Valley/S 180 | $1.8 | $1.6 | 10% | |
| | 224/228 CORRIDOR | | | | |
| Kent | S 228, Russell - Military | $7.8 | $3.1 | 10% | 50% |
| Kent | S 224, SR-515 - SR-167 | $7.8 | $3.1 | 10% | 50% |
| | OAKESDALE | | | | |
| Renton | Oakesdale, SW 28 - SW 16 | $5.5 | ($0.0) | 10% | 90% |
| Renton | Oakesdale, SW 16 - Sunset | $11.0 | $8.3 | 25% | |
| | STRANDER EXTENSION | | | | |
| Renton | SW 27, W Valley - SR-167 | $8.0 | $6.4 | 20% | |
| | SOUTHCENTER BLVD | | | | |
| Tukwila | Southcenter Blvd, T-Line - Grady | $7.7 | $6.1 | 20% | |
| | PUGET-EDMONDS | | | | |
| Renton | SE Puget, Edmonds - SR-169 | $10.0 | $9.0 | | 10% |
| Renton | SE Puget, Jones - Edmonds | $1.0 | $0.9 | | 10% |
| Renton | Edmonds, SR-169 - NE 3 | $4.0 | $3.6 | | 10% |
| | FREEWAY INTERCHANGES | | | | |
| WSDOT | I-5/S 200 Conn/SR-509 (Kent) | $10.0 | $0.0 | 100% | |
| WSDOT | SR-18/SE 277 Ext (King) | $5.0 | $4.5 | | 10% |
| WSDOT | I-405/SR-515 (Renton) | $10.0 | $10.0 | | |
| WSDOT | SR-167/SW 43 (Renton) | $5.0 | $0.0 | 100% | |
| WSDOT | SR-18/SR-164 (Auburn) | $8.0 | $0.0 | 50% | 50% |
| WSDOT | SR-18/S 312 (King) | $6.0 | $0.0 | 100% | |
| WSDOT | I-5/S 178 (Tukwila) | $10.0 | $10.0 | | |
| WSDOT | SR-167/SW 27 (Renton) | $7.0 | $7.0 | | |
| WSDOT | SR-167/S 192 (Kent) | $5.0 | $5.0 | | |
| | Local Jurisdiction Total | $129.4 | $75.2 | 13% | 28% |
| | WSDOT Total | $66.0 | $36.5 | 38% | 7% |

formation of a district encompassing all or part of the Action Plan area to implement the Action Plan projects. This ruling could provide a mechanism for the Action Plan jurisdictions to forge a partnership among themselves, property owners, and citizens within the district boundaries for jointly funding some or all of the extraordinary projects.

The cities and King County can use and have in the past used local taxes and bond issues supported by voter-approved property tax levies to pay for transportation projects. In 1968 an $80 million bond issue was approved by King County voters to provide urban arterial improvements throughout the county. Many of the projects funded by this bond issue were located in the study area. However, transportation projects face intense competition from a variety of other public needs for local taxes and bond revenues. This competition has kept the Action Plan jurisdictions from financing more than a small fraction of their transportation projects with local revenues.

The final sources of funding that were assessed were those that could be raised within the study area itself, primarily through assessments and contributions from property owners. In theory, the Action Plan jurisdictions could form one or more districts within the study area and ask the residents and property owners within the districts to finance all or a portion of the Action Plan projects. In practice, they have found it difficult to gain the voluntary cooperation of the voters and property owners. Instead, the Action Plan jurisdictions have been using the power given them by the state's environmental laws to condition the approval of development permits on agreements by the property owner to mitigate the on-site and off-site transportation impacts of their proposed projects. To

# Public Involvement Process for Identifying Problems and Alternative Solutions for the Year 2010 Transportation Plan

PATRICK DE CORLA-SOUZA, HAROLD SALVERDA, AND DAVID BECKWITH

**The objectives of the Toledo Metropolitan Area Council of Governments (TMACOG) for public involvement in development of its Year 2010 Transportation Plan were (a) to assist system planners in obtaining a better understanding of the system users' problems, (b) to allow as many solution options as possible to surface, (c) to obtain the assistance of the public groups in plan evaluation so that the plan would truly meet their needs, and (d) to build a broad base of ownership and understanding of the plan and attract a broad base of support for individual projects on the plan. With these objectives in mind, the Long-Range Plan Task Force was established and became the body responsible for developing and implementing an innovative public involvement process. A series of five public meetings were held at scattered locations throughout the TMACOG region, culminating in a "Charrette," an intensive brainstorming session held over a short period of time. The purpose of the five pre-Charrette public meetings was to identify the transportation issues, problems, and needs within each geographic subarea, to assure that adequate information on subarea problems would be available at the Charrette, and to generate interest and excitement about the Charrette. The Charrette itself, which had more than 100 people participating within thematic subgroups, was intended to unlock the creativity of the participants by focusing their attention intensively over a period of 24 hours on solutions to transportation problems facing the Toledo area. The spirit of cooperation and trust fostered by the Charrette was maintained by the Long-Range Plan Task Force through its subgroups as they refined the ideas from the Charrette and developed plan alternatives for testing and evaluation. The most important outcome of the Charrette was the fact that over 100 community leaders have a better understanding of their stake in transportation planning and have ownership of the Year 2010 Transportation Plan.**

Historically, the Toledo Metropolitan Area Council of Governments (TMACOG) has recognized that the normal committee process used to assist decision making has a number of defects when attempts are made to use it to solve regional problems (*1*). This method, which is often referred to as the hierarchical method, is a process that gathers input from a variety of sources—citizens, staff, and policy experts—and grinds it through committee meetings, where all aspects of problems and solutions are identified. The final policy-making body ultimately draws everything into a single, simple conclusion.

Although this process has merit—it provides a decision-making framework whose ground rules are widely accepted—it does not encourage creative thought in the understanding of problems and the development of solutions. Neither does it readily allow the use of the rare "off the wall" observations from lay people and experts that add a valuable dimension to the decision. Therefore, over the past two decades, TMACOG staff members have looked for other methods, particularly in the field of "group dynamics," to supplement the committee method. The need for other methods was especially acute in those cases in which committees have indicated that they need an outlook broader than their own inhibited one for the identification of problems and solutions.

When TMACOG set out to begin the process for development of its Year 2010 Transportation Plan, the limitations of the committee method were recognized:

- Creative thought is inhibited;
- The number of transportation problems and solutions that can be handled is limited;
- The policy-making groups responsible for making the final decision do not receive the problems and solutions in their original context or form;
- Viewpoints and priorities tend to be rigid; and
- Committee members do not always "buy into" the group decision if it is different from their own view, and the decision therefore may lack a broad base of support.

Because of these limitations, TMACOG staff members designed a new and innovative public involvement process to obtain input for the development of TMACOG's Year 2010 Transportation Plan. The process design focused on "group process" techniques. It was different from what most regional transportation agencies have done in the past in several ways:

- Substantive input from the public would be sought at the very beginning of the plan development process, before any lines were drawn on maps;
- A concept previously used successfully at the project development level, called the "management team" process (*2*), would be attempted at the regional scale to guide the entire plan development process; and

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• TMACOG would seek to focus its efforts on a major public meeting called a "Charrette."

The Charrette (*3*) is a process that brings together conflicting interests for a concentrated block of time, such as a weekend or a series of nightly meetings. All major public groups are represented. Charrettes normally bring together a small group of people who seek to reach a consensus on solutions to a well-defined physical problem related to planning or development (*4*). TMACOG's proposed Charrette would attempt to expand the traditional use of the process by using it to define problems in addition to seeking solutions, to develop solutions for physical problems widely scattered throughout the region, instead of only at one specific location, and to bring together a large group (about 100 people) representing major interests throughout the region, instead of the 10 to 20 people that usually come together at Charrettes.

## PROCESS OBJECTIVES

The first objective of the public involvement process was to allow transportation system planners and technicians to develop a better understanding of the system and its problems from system users. The system user can provide a different and more intimate perspective on the impediments and discomforts of the system and can help verify whether objective data collected by system planners match the perceptions of users of the system.

The second objective of the process was to ensure that the intuition of individuals in the group is allowed to surface in the identification of possible solutions. All members of the group were to be brought together on a even basis so that the less forceful participants could be braver in offering ideas, while the more forceful would have to reduce their domination. If participants can take part on an equal footing in the absence of hierarchical structures, the solutions that emerge may be of better quality.

A third objective of the process was to ensure that a feeling of ownership of the plan and the planning process would develop among the participants. For ownership to develop, the participants in the process should all feel that they are each an important part of the planning process and that their views and contributions are being given due consideration. If participants have shared in the development of solutions, they will be more willing to support fully the plan that results, even though it may not reflect their personal priorities or those of the organizations that they represent. Also, they will be more committed to attracting the funding support needed to implement each of the projects in the plan.

The fourth objective of the process was to allow the public groups affected by proposed solutions to participate in the evaluation of all aspects—safety, environmental, political, social, and economic—of proposed solutions and to do so early in the process, before any "lines" are drawn on maps and before system alternatives are developed for computer testing.

## DESIGN OF THE PROCESS

The existing decision-making process for TMACOG's transportation programs is shown in Figure 1. A technical subcommittee called the Streets and Highways Subcommittee (consisting of engineers who represent TMACOG's member jurisdictions) makes recommendations to two transportation advisory committees called the Urban Area Citizens Advisory Committee (UACAC) and the Urban Area Technical Advisory Committee (UATAC). As its name suggests, the UACAC is composed of citizen representatives from TMACOG's member jurisdictions and various community organizations, whereas the UATAC is composed primarily of government representatives. These advisory committees make recommendations to a policy board called the Transportation and Land Use Committee (TALUC) that represents the TMACOG transportation study area. TALUC makes decisions on all transportation issues, subject to endorsement by the Executive Committee of TMACOG, a policy board that represents the entire TMACOG region.

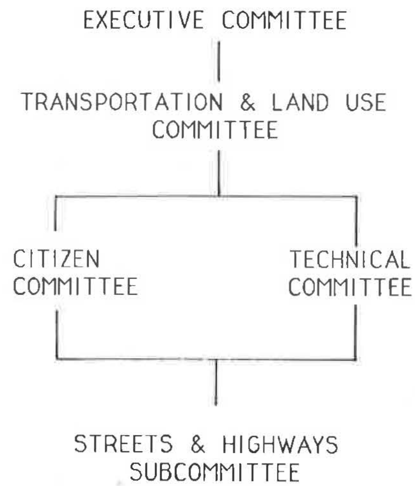


**FIGURE 1 TMACOG committee structure.**

Efforts were made to augment this process for development of the Year 2010 Transportation Plan so that it would include broader-based public involvement. At the same time, plans were made to reduce the extensive delays that could occur if decisions had to be endorsed by each TMACOG committee at every intermediate step in the 2010 plan development process, as laid down in TMACOG's process flow chart. The steps that were of concern were the development of evaluation procedures, estimation of financial resources, problem identification, development of alternative plans, and evaluation of alternative plans. It was felt that formal review by each committee should occur only at critical points in the process and not necessarily at every intermediate step. With assistance from the chairs of the committees, a new committee called the Long-Range Plan Task Force was conceived to undertake review at the intermediate steps. The task force would consist of citizens from UACAC, technicians and government officials from the Streets and Highways Subcommittee and UATAC, and elected officials from TALUC and the Executive Committee. It would also include representatives of other interest groups. The Long-Range Plan Task Force would work to secure input and ideas on problems and solutions from the various public groups, and to maximize ownership of the plan by all segments of the community.

As a result of meetings with various committee chairs and key members, consensus built toward a Charrette as the preferred technique for securing citizen involvement early in the

| STAGES OF PLAN DEVELOPMENT | DEVELOP FORECASTING PROCEDURES | DEVELOP INFORMATION FOR FORECASTING | DEVELOP EVALUATION PROCEDURES | ESTIMATE FINANCIAL RESOURCES | IDENTIFY FUTURE PROBLEMS | IDENTIFY ALTERNATIVE SOLUTIONS | DEVELOP ALTERNATIVE PLANS | EVALUATE ALTERNATIVE PLANS | PREPARE AND ADOPT PLAN |
|---|---|---|---|---|---|---|---|---|---|
| PARTICIPANTS | | | | | | | | | (may include redoing stages 6-8 if new alternatives are uncovered) |
| TMACOG Ex. Comm. | (N/A) | Ex. Comm. approval 1/85 | (N/A) | (N/A) | Ex. Comm. TALUC | CHARRETTE (4/87) | | | Exec. Comm. adoption 4/88 |
| Transportation Advisory Committees and TALUC | TALUC approved procedures in 9/86 | TALUC approval of policies and assumptions 1/85 | TALUC to adopt goals, objectives and process 12/86 | (N/A) | (Pre-charrette media involvement | | Advisory Committees and TALUC to approve alternative plans by 7/87 | | TALUC to adopt plan in 4/88 |
| Charrette/ Public Meetings | (N/A) | (N/A) | (N/A) | (N/A) | Region-wide concerns | Subject area portion; Geographic area portion | | Neighborhood meetings in 1/88 | OUR PLAN<br>UATAC and UACAC review plan in 3/88 |
| Streets and Highways Subcommittee of UATAC | (N/A) | (N/A) | (N/A) | (N/A) | UATAC<br>UACAC<br>Streets & Hwys. Task Force | Sts. & Hwys. reviews alternate solutions | Streets & Hwys. Subcommittee reviews alt. plans, early 6/87 | (N/A) | Streets & Hwys. Subcommittee reviews by early 3/88 |
| Task Force with mainly TALUC, UATAC, and UACAC representatives | (N/A) | (N/A) | Ad-hoc Task Force assisted staff and identified goals and objectives through 11/86 | Task Force will review estimates in 2/87 | Task Force helps coordinate pre-charrette activities and provides qualitative information 3/87 | Task Force shares in conducting the charrette, and reviews input from econ. devel. professionals in 3/87 | Task Force reviews and refines output from charrette and prepares 5-10 feasible alternative plans for evaluation, 5/87 | Task Force provides qualitative information for neighborhood meetings (12/87) and reviews and refines output from meetings (2/88) | Task Force uses output from neighbor-meetings to prepare final plan, 2/88 |
| TMACOG Staff | Staff completed development of procedures in 7/86 | Staff completed work in 7/86 | Staff developed procedures through 11/86 | Staff will prepare estimates in 1/87 | Staff provides quantitative information in 3/87 | Staff seeks input from econ. devel. professionals 2/87 | Staff provides information on impacts of extremes 5/87 | Staff provides quantifiable impacts of alternatives 12/87 | Staff compiles public comments in 2/88 |
| | <--------STAGES | COMPLETED--------> | <-------STAGES | UNDERWAY------> | <--------------STAGES | | Not yet begun. | | ----------> |

FIGURE 2 TMACOG's 2010 Transportation Plan development process.

process. In the design for public involvement, as indicated in Figure 2 (*5*), the Charrette became the centerpiece of the initial phase of plan development. Its end product was to be a list of prioritized problems and suggested solutions. The Long-Range Plan Task Force would prepare for the Charrette, implement the Charrette process, and refine the output from the Charrette to develop plan alternatives. In the next phase of plan development—evaluation of alternative plans—a series of public meetings would be conducted throughout the region, and the task force would then prepare the final plan on the basis of public input from the meetings.

In fall 1986, the various TMACOG committees discussed at their meetings the planning process that had been designed jointly by their chairs. Because these group leaders had been intimately involved in the design of the process, all members of each committee began to feel that they had ownership of the process. The process was adopted by each committee, and each committee named its representatives to the task force.

## PREPARATION FOR THE CHARRETTE

In December 1986, the Long-Range Plan Task Force met for the first time and formed five subcommittees to research and recommend actions for the Charrette. The committees dealt with the following elements:

*Process and Leadership*. This group's assignment included finding a keynote speaker who could inspire those present to think creatively. They also had to recommend facilitators for the smaller groups into which the larger group would be subdivided and to choose a date (or dates) for the Charrette.

*Themes*. These committee members were told to recommend the subject matter for each subgroup.

*Location*. Recommendation of an appropriate location that would cause the participants to "think regionally" was the charge of this group.

*Participants*. This group recommended organizations or specific persons who should be invited to the Charrette.

*Pre-Charrette Publicity and Public Relations*. This subcommittee was instructed to recommend ways to ensure that the public would be aware of the coming event and its importance and to maximize participation by key community leaders.

To ensure that adequate input by geographic area would be obtained, the task force proposed a series of five pre-Charrette meetings to be held at scattered locations throughout the region. The purpose of these meetings would be to provide pre-Charrette interest, background, and discussion among participants, to identify the transportation problems and needs within each geographic area, and to ensure that adequate information on subarea problems would be available to participants at the Charrette.

A list of 188 potential nominees was compiled from nominees recommended by individual members of the task force. The list included elected officials, technicians, transportation providers, major employers, development interests, neighborhood organizations, and other key groups in the Toledo area. About 120 nominees were selected, and members of the task force assisted with invitations, making personal telephone calls to invite the nominees to pre-Charrette meetings and to the Charrette.

## PRE-CHARRETTE PUBLIC MEETINGS

Pre-Charrette meetings were held in five subareas of TMACOG's planning region over a period of 2 weeks in March 1987. The main task at these meetings was to elicit the participants' perceptions of the transportation problems that they anticipated through the year 2010 and to group these problems by theme for consideration by theme subgroups at the Charrette. However, the meetings were also designed to get participants to "buy into" the process; to demonstrate that TMACOG really intended to listen to them; to stimulate interest and creativity with creative displays; and to show that TMACOG could do a professional job in presenting information and facilitating meetings.

By far the most challenging of the premeeting activities was the development of appropriate displays and slides to set the mood for brainstorming and creative thinking at the meeting while at the same time conveying necessary information for informed discussion. After registration, meeting attendees moved through five stations in the exhibition area. Each station displayed information on one of five proposed Charrette themes. Seating was located around a final work station for use during a brainstorming session in which two facilitators worked jointly to record on a map the various problems suggested by the participants. Next the problems were clustered by category. Titles for general clusters were first solicited from the participants, and each title was written on a sheet of newsprint. The participants were then asked to pick all those problems on the map that belonged in each cluster group. The clustering of problems was designed to assist in finalizing the theme topics to be used in the Charrette. During the final phase of the meting, participants were asked to sign up for one cluster group to serve as representatives of the subarea meeting in the Charrette theme subgroups. The names of these volunteers were listed with each problem cluster on the newsprint sheets.

By the conclusion of each pre-Charrette meeting, the participants had seen and understood the information available about the region and had together created the list of problems to be addressed at the Charrette. The process served to build up the "eventness" of the Charrette and increased the participants' commitment to the process. The high-quality, informative displays and the prompt and professional handling of the meeting agenda further convinced the participants that TMACOG really "had its act together."

A report on the pre-Charrette meetings was developed (*6*). The report listed the problems that surfaced at all five meetings. These problems were grouped into one of five theme groups, and a map for each theme illustrated the listed problems. The report was provided to all Charrette participants a few days in advance of the Charrette so that they could review it, be prepared for the event, and see how their subarea meeting group agreed—or disagreed—with groups at other subarea meetings.

## CHARRETTE: DAY ONE

The physical arrangement of the hall used for the Charrette included a central seating area focused on a giant map of the

PROBLEM TRACKING FORM

2010 TRANSPORTATION PLAN CHARRETTE

____________

PROBLEM ID#

I. DISCRIPTION:

II. List of solutions to this problem:

| | |
|---|---|
| 1.______ | 11.______ |
| 2.______ | 12.______ |
| 3.______ | 13.______ |
| 4.______ | 14.______ |
| 5.______ | 15.______ |
| 6.______ | 16.______ |
| 7.______ | 17.______ |
| 8.______ | 18.______ |
| 9.______ | 19.______ |
| 10.______ | 20.______ |

III. Place * next to "Preferred Solutions" and list them under item IV on the reverse side.

IV. For each "Preferred Solution", assign a score from 0 to 10 (0 is poorest, 10 is best) relative to the following criteria:

A. Solution increases the competitive advantage of Toledo area vs. the rest of the world.
B. Creates new non-construction job opportunities.
C. Reduces the delay of traffic.
D. Helps make transit more viable.
E. Reduces the risk (or frequency) of accidents.
F. Does not create many new problems.
G. Has a good benefit to cost ratio.
H. Solution is creative.

| Preferred Solutions | Criteria Scores A | B | C | D | E | F | G | H | Total Score |
|---|---|---|---|---|---|---|---|---|---|
| 1.______ | | | | | | | | | |
| 2.______ | | | | | | | | | |
| 3.______ | | | | | | | | | |
| 4.______ | | | | | | | | | |
| 5.______ | | | | | | | | | |
| 6.______ | | | | | | | | | |
| 7.______ | | | | | | | | | |

V. Re-list Preferred Solutions in order of scores:

1.______
2.______
3.______
4.______
5.______
6.______
7.______

**FIGURE 3 Problem tracking form used during the Charrette.**

region, with work areas laid out on the perimeter of the room. Displays of data on the region's economy, land use, transportation systems, and growth trends were posted around the room, with information that related to a particular theme located in the appropriate work area. The problems suggested at the pre-Charrette meetings were posted on the walls on "problem tracking forms" (Figure 3) in the appropriate work group area. The five theme groups were

- Transportation as it Impacts Development,
- Transportation on Freeways and Across the Maumee,
- Transportation on the Street System,
- Transportation of People: Non-Automobile, and
- Transportation of Goods.

Each government entity in the region was represented. Elected officials, consumers, and providers were present, and participants included truck owners, road builders, bicycle riders, freight train users, developers, environmentalists, handicapped rights activists, public transit executives, leaders of professional organizations, and neighborhood leaders—all the parties that would be affected by the plan to be developed.

The Charrette was held from 4:00 p.m. on Thursday, April 2, 1987, until 2:30 p.m. on Friday, April 3, 1987. Several of the participants were on hand even before the registration time at 4:00 p.m. on Thursday—an indication of the high level of interest that had been generated. A microcomputer (Figure 4) that was located in the center of the room to demonstrate technical planning procedures drew a considerable number of the early arrivals. At 4:30 p.m. the Charrette Facilitator provided the opening instructions. Each participant was asked to pair up with another participant in the same theme subgroup. Each pair of participants was provided with an assignment sheet, which was to be filled in after reviewing the identified problems that were stated in bold letters on the problem tracking forms that were posted on the wall. The pair would note on the assignment sheet at least one problem that might affect the issues that their theme group had been assigned to address and at least one problem from their theme group's list that might affect another group's issues (Figure 5). The purpose of the assignment was to familiarize the participants with problems that had already been identified at the pre-Charrette meetings.

The assignment was followed by dinner. The dinner seating was by theme group to foster communication and group identity. After the dinner, the keynote speaker, a national figure in the transportation field, provided information on and insight into trends in funding and planning for transportation systems (Figure 6).

The next event was the first meeting of the theme groups. Each group completed the list of problems assigned to it (Figure 7). As new problems were suggested, the group facilitator located them on a map, while the recorder wrote them down on a new problem tracking form, which was then posted on the wall. This gave any participant who did not attend a pre-Charrette meeting an opportunity to buy into the problem list.

**FIGURE 4 A microcomputer was used to demonstrate technical planning procedures on the first day of the Charrette.**

**FIGURE 5 Pairs of participants from the theme groups examine problems as part of the first day's activities.**

**FIGURE 6 The keynote speaker addresses the participants at the working dinner on the first day.**

**FIGURE 7 After dinner on the first day, the theme groups work to complete their problem lists.**

After each group had listed additional problems, its members reviewed the entire list to consolidate similar problems and clarify the problem statements (Figure 8). Occasionally, the group would feel that one of their assigned problems should be discussed by another theme group. The problem tracking form for that issue would be given to a group volunteer who would take it over to the group that was the most appropriate to handle the matter (Figure 9).

After trading problems, each group consolidated the problem statements that remained. Finally, they prioritized the problem statements that were still posted. Each participant was given five votes to "spend" on any five problems. Participants then raised their hands to vote for the five most important problems in the region. The problem with the highest total votes was the most important problem for the group as a whole.

The program ended for the night with the whole Charrette group moving from one theme work area to the next to listen to group reports, to see if one group's problems might affect another group, and to get an overview of the transportation problems facing the whole region.

## CHARRETTE: DAY TWO

The second day's activities focused on solutions. Several participants arrived before the appointed time of 7:30 a.m., again indicating the eagerness of the participants to get back to work. The first item of business was for each theme group to discuss the following questions: Were there problems on its list that another group should handle because of related issues on the other group's list? Or were there problems on another group's list that should be handled by their group? In either case, the participant who suggested a switch went to the other group and negotiated the switch.

Each group then began to work on the development of solutions. The group was divided into clusters of two to four people. This division was arbitrary and was made by the group facilitator, who ensured that each cluster consisted of people with diverse backgrounds. Next, the problem tracking forms that had been posted on the wall were distributed to the cluster groups by an "auctioning" process (Figure 10). The group

**FIGURE 8 Members of a theme group consolidate and clarify their list of problems.**

**FIGURE 9 A volunteer runner carries an unwanted problem form from his theme group to a more appropriate group.**

**FIGURE 10 On the second day, a theme group facilitator "auctions" a problem to her group's solution clusters.**

facilitator removed a problem form from the wall, read it, and asked which cluster wanted it. The problems that had been given high rankings by the theme group on the previous night were auctioned off first. The group facilitator tried to ensure that each cluster had a reasonable number of problems to handle and that the problems assigned to any one cluster were similar.

The group facilitator then instructed the cluster groups on procedures for the development of solutions. The goal was to work quickly and cover a large number of ideas rather than to develop one or two in great detail. The rules were as follows:

- Do not consider practicality: record all "wild" ideas.
- Think about how the world will be different in 2010 and how that could change a problem or open up new solutions.
- Look for ways to reduce the magnitude of the problem, such as by changing transportation modes.
- Look for ways to reduce the magnitude of a problem by fixing something at another location.
- Look for both low-cost, short-term fixes and expensive, longer-term fixes.

Each problem tracking form had 20 short blank spaces. The cluster groups proceeded to fill in as many of the blank spaces as they could, putting down every idea that crossed their minds, no matter how wild (Figures 11 and 12). By break time, which

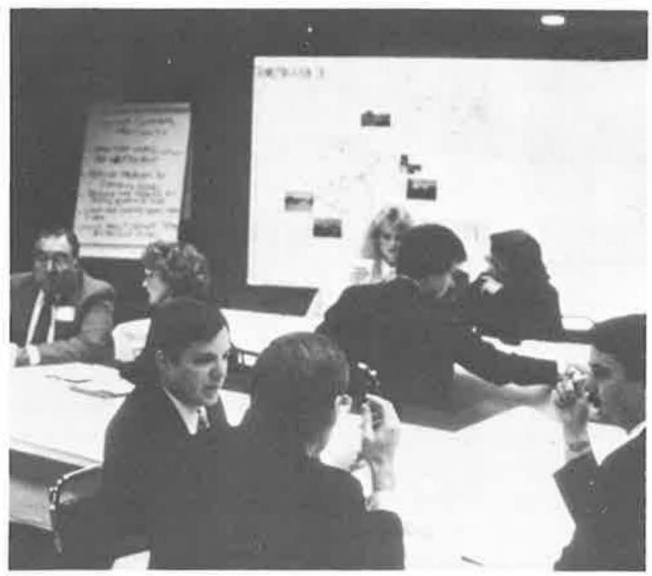

**FIGURE 11 The cluster groups organized on the second day brainstorm to come up with solutions to their assigned problems.**

was scheduled for 10:00 a.m., most cluster groups had completed work on the problems assigned to them. Those that didn't worked through the break. After the break, each cluster group reported to the theme group on its most practical and most extreme ideas. Each cluster group then selected a few preferred solutions for each problem and proceeded to analyze them (Figure 13) on the back of the Problem Tracking Form (Figure 3). The evaluation proceeded as follows. Each preferred solution was given a numerical score (0 to 10) related to

**FIGURE 12 A large map helps these cluster group members to solve their assigned problems.**

**FIGURE 13 Members of a cluster group analyze their preferred solutions.**

several criteria that had been developed on the basis of the 2010 plan goals and objectives (*5*) that had been adopted by all TMACOG committees. Scores were then totaled across all criteria for each solution. The total scores for each solution were then used by the cluster group as a guide to the final ranking of the preferred solutions.

Cluster groups then began preparing their reports, which were scheduled to be made to the full Charrette group. Blank maps had been provided to all cluster groups for use in developing solutions. These maps were also used by the groups to prepare graphics to be used in their reports (Figure 14). Over lunch, the cluster groups began their presentations (Figure 15). One cluster group from each theme group was called to speak until all theme groups had had one of their cluster groups on stage, after which a second round of reporting began. There was considerable discussion after each report.

The Charrette adjourned with a wrap-up from the Chief Facilitator, recognition of task force members and support team, and a final ceremonial signing, by each participant, of giant letters transmitting the Charrette results to the task force for consideration in development of the Year 2010 Transportation Plan.

**FIGURE 14 Members of a cluster use one of the blank maps provided by the Charrette planners as an illustration in their cluster presentation.**


**FIGURE 15 The cluster groups from each theme group take turns in presenting their problem solutions at the working lunch on the second day.**

## EVALUATION OF THE CHARRETTE PROCESS

By the conclusion of the Charrette, it was clear that TMACOG had made great progress toward achieving its initial objectives for public involvement. A list of prioritized problems and alternative solutions to address them had been obtained (*7*). The most important end product of the Charrette, however, was the fact that over 100 key community leaders now better understood their stake in transportation planning and had ownership of the solutions proposed for the Year 2010 Plan, which was to be produced over the next several months. Their contribution to plan development ensured that the Year 2010 Plan would be a better plan and that it would have a broad base of support for attracting a higher level of transportation funding.

Several elements in the process could have been more effective. First, identification of problems received a disproportionate emphasis at the Charrette in comparison with the time spent on generating and evaluating solutions. A brief look at solutions by the theme groups by the end of the first day could have overcome this problem. The group reports at the end of the first day could then have served to add stimulation for creative thinking on the next day.

Second, a disproportionate amount of effort was expended by the cluster subgroups to score each solution against several criteria. Some of this time could have been better spent in sharing their recommendations with the rest of the theme group and modifying the recommendations on the basis of discussion within the theme group. Such interaction among cluster groups would not only have contributed to a better quality product but would also have generated a higher level of ownership of the prioritized solutions by all theme group members.

Third, the final reporting session (from noon to 2:30 p.m. on the second day) was too long. It began with great excitement but soon began to deteriorate because one report was usually unrelated to the next. Also, theme groups should have been brought back together after the reporting session to modify and finalize their recommendations on the basis of what they had heard at the reporting session. This would have effectively utilized the interaction among theme groups to produce a better product.

## POST-CHARRETTE PROCESS

Over the 6-month period between April and October 1987, the Long-Range Plan Task Force molded the output from the Charrette into alternative highway system plans and transit system plans for computer testing and subsequent development of the Year 2010 Transportation Plan. Significant steps in the post-Charrette process were (a) evaluation of the Charrette, both successes and disappointments, (b) clarification and refinement of the problem and solution lists from the Charrette and further definition of intangible solutions—primarily policies involving land use or travel—to allow computer testing and evaluation of their effects, and (c) development of financially constrained alternative transportation plans for computer testing and development of a strategic highway plan for the year 2010.

### Process Evaluation

A debriefing of task force members and the support team was held immediately after the Charrette. Later, more formal evaluation surveys were undertaken, including a survey of all TMACOG staff who assisted in the Charrette and surveys of task force members and Charrette participants.

### Refinement

The lists of solutions were documented in a special report (*7*). The next step was to refine these solutions and to also address those problems that the Street System Subgroup had not been able to address at the Charrette because of time constraints. The task force members were divided into five subgroups by theme. Charrette participants and other key people who were not task force members were added to the subgroups when the subgroup members thought that such additions were appropriate. This subgroup process had not been envisioned before the Charrette and was a spontaneous result of the high level of interest displayed by several of the Charrette participants, who expressed a desire to continue their involvement in the process. The work of the task force subgroups was incorporated into a report (*8*) that not only documented the refined solutions and their ranks but also categorized the nonproject solutions into land use, travel, and other issues.

To refine and clarify nonproject solutions, the task force formed three "issue" subgroups that again brought in key participants from the Charrette who had expressed interest in being involved in specific issues. The first subgroup's charge was to further define land use policy alternatives, the second was to further define travel policy alternatives, and the third was to address the following questions relating to other issues that were not amenable to testing by computerized travel models:

- How should other policy issues be evaluated?
- Should other policy issues be considered in development of the 2010 Plan?
- If not, by whom and when should they be dealt with?

It was important to deal with these questions because several solutions that emerged from the Charrette (such as rail, airport, seaport, truck, and elderly and handicapped mobility issues) were related to issues that are not normally dealt with in the long-range transportation plan that TMACOG is responsible for developing.

The end products of the three issue subgroups (*9*) were the following:

- Land use policy alternatives (from the Land Use Issues Subgroup);
- Travel policy alternatives (from the Travel Subgroup);
- Organizational structure for evaluation and selection of policies related to other issues that should be considered in the 2010 plan (from the Other Issues Subgroup); and
- A list of highway projects prioritized by each issue subgroup for further consideration in the development of alternative highway plans for computer testing.

### Development of Alternative Transportation Plans

The task force reviewed the work of the three issue subgroups (*9*) and set up four new subgroups, which again included key Charrette participants. A Transit/Ridesharing Subgroup was formed to review travel policy alternatives related to transit and ridesharing, and three subarea subgroups were formed to review and prioritize highway projects within each of three geographic subareas.

The Transit/Ridesharing Subgroup developed a set of transit and ridesharing policies. These policies were recommended to the task force for computer testing (*10*) and were adopted by the task force. The three subarea subgroups prioritized all projects proposed within their respective geographic subareas (*11*). By using the regional project priorities that had been developed previously by the issue subgroups and the geographic priorities developed by the subarea subgroups, the task force then developed for computer testing two alternative financially constrained highway system plans and a single draft strategic needs-based highway plan (*12*) representing the financially unconstrained highway improvement needs of the region.

The draft strategic highway plan developed by the task force is the final project output of the Charrette because it includes all of the highway projects suggested at the Charrette, refined, screened, or modified by the Task Force. After a technical review of traffic impacts of the draft Plan by TMACOG staff on the basis of a computerized traffic assignment of forecasted year 2010 vehicular traffic on the system, this plan will be refined by the task force to become TMACOG's 2010 Strategic Highway Plan.

## CONCLUSION

At the time of writing (February 1988), 10 months had passed since the Charrette. The spirit of cooperation and trust that had been fostered by the Charrette was still being maintained and reinforced by the task force. References were frequently being made to Charrette sentiment with respect to policies and projects during the deliberations of the subgroups and the task force, and public input obtained at the Charrette was being used to give shape to the final Year 2010 Transportation Plan.

A clear indication of the success of the public involvement process is the ease with which ownership of the transportation plan alternatives developed throughout TMACOG's committee structure. The two alternative financially constrained highway plans, the draft strategic highway plan developed by the task force, and the transit/ridesharing policy recommendations were adopted by the Streets and Highway Subcommittee, UACAC, UATAC, and TALUC as though they were routine decisions. Members of each committee who had participated in the task force deliberations spoke strongly at their respective committee meetings in favor of the consensus decisions of the task force.

The authors expect the final plan development and adoption process to build upon the positive experiences documented in this paper. After adoption by TMACOG, the plan will be taken to the local member governments for adoption. A measure of the success of the process will be the ease with which the plan is adopted by city councils and county commissions whose representatives were involved in the Charrette process. The final measure of the success of the process, of course, will be the extent to which the region is successful in getting region-wide public support as each project on the plan proceeds to the implementation phase over the next 20 years.

## ACKNOWLEDGMENTS

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*The contents of this paper do not necessarily reflect the official views or policies of the Federal Highway Administration, which is the current employer of the first author.*

# Miami Downtown People Mover Demand Analysis Model

KATHIE G. BROOKS AND MYUNG-HAK SUNG

**Various methods for estimating Downtown People Mover (DPM) System demand have been developed and applied in DPM planning activities in many different cities since the early 1970s. In addition, the UMTA Office of Planning Methods and Support sponsored the development of a report of state-of-the-art methods for DPM system planning that included suggested DPM demand estimation procedures. As part of the detailed studies and evaluations conducted in accordance with UMTA guidelines, the city of Miami, Florida, adopted the method suggested by UMTA, with some modifications, and applied it to the Miami DPM system (Metromover) preliminary engineering project. The full Miami system, consisting of the Central Business District (CBD) Loop with the Omni and Brickell legs, was selected and adopted through this process. Because there was insufficient federal funding for the entire project, it was agreed that the downtown loop would be built initially. The CBD Loop portion of Metromover became operational in April 1986. The completion of the full Metromover system with the Omni and Brickell legs is in the process of Environmental Impact Statement (EIS) preparation. For the Omni and Brickell legs EIS project, it became possible to update the Metromover demand analysis model and validate it against actual Metromover ridership. This paper presents a description of the Metromover demand analysis model, the model validation process and results, and the model's application to future Metromover legs. Recommended future modifications to the Metromover demand analysis model also are discussed.**

Since the early 1970s, Metro-Dade County, Florida, has maintained a consistent policy of promoting public transportation as a major component of the regional transportation system. A comprehensive planning and preliminary engineering program led to the construction of the first phase of the Metrorail system, which is currently in operation. It was recognized that the metro line's location along the fringe of downtown Miami created the need for a distribution system to move people between Metrorail's downtown stations and their eventual destinations within the central business district (CBD).

In 1974, the Urban Mass Transportation Administration (UMTA) announced the Downtown People Mover (DPM) Demonstration Program. The underlying objective of this program was to demonstrate the viability of fully automated people mover systems in urban settings. Miami was selected to participate in the program on the basis of the merits of its proposed downtown application.

Detailed studies and evaluations conducted in accordance with UMTA guidelines resulted in the selection of a Metromover line consisting of a 1.9-mi loop around the traditional core of downtown Miami (the CBD Loop), a 1.4-mi connection to the Omni area (the Omni Leg), and a 1.1-mi connection to the Brickell area (the Brickell Leg).

Because traditional travel demand forecasting procedures are limited in their ability to evaluate downtown circulation and distribution travel demands, specialized travel demand forecasting techniques were required. A set of DPM demand estimation procedures was recommended by UMTA in the report *Planning for Downtown People Movers* (*1*). These procedures were based primarily on an integrated set of activity center travel demand models developed and applied to predict circulation and distribution travel in downtown Los Angeles. Modifications were made so that the models would be generally applicable to other U.S. cities.

The demand estimation procedures used in selecting the full 4.4-mi Metromover alignment were based on this travel demand model and validated for Miami. Because of the complete lack of data for any downtown DPM system at the time, the original Miami model (*2*) was validated by using the downtown circulator bus system. Preliminary engineering studies were conducted in 1980 for the full system. Because of insufficient federal funding, the project was separated into two parts: first, the CBD Loop, and second, the Omni and Brickell legs. It was agreed that the CBD Loop would be built initially.

In December 1985, Congress legislated preparation of the Environmental Impact Statement (EIS) for completion of the Metromover System. The EIS is required to present the projected transportation and environmental impacts for the legs (the Build Alternative) and the base (No-Build Alternative). To predict the transportation impact of the legs, the model had to be able to simulate two different transportation functions: the distribution of trips from the region into the expanded CBD, and the capabilities of the legs to act as an integral part of the circulation system for intra-CBD trips.

The Metromover CBD Loop opened for service on April 17, 1986. This was the first DPM system operational in a downtown environment in the United States. As a result, data were available for the first time to validate the previously developed DPM demand estimation procedures. The following sections present a description of the updated Metromover demand analysis model, the model validation process and results, and the model's application to the future Metromover legs. Recommended future modifications to the Metromover demand analysis model also are discussed. Detailed description of the original UMTA model can be found in *Planning for Downtown People Movers* (*1*).

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## DPM DEMAND ANALYSIS MODEL

There are two potential trip markets for downtown areas. The first market consists of trips with either an origin or a destination outside the downtown area, referred to as the external-internal trip market. The second market consists of trips that are generated and have destinations within the downtown area, referred to as the internal trip market.

The external-internal market is separated into three segments on the basis of the mode used to enter the downtown area: automobile, rail, and bus. The model predicts the parking location for automobile trips entering the study area and the mode of travel to the final destination from the parking lot. The modes available for the final segment of the automobile trip include walking, riding the regional transit (Metrobus and Metrorail), or using the distribution and circulation (D/C) system, including the Metromover System. Metrorail trips that enter the downtown area are handled in a similar manner. The model predicts the station that each rider uses to exit the Metrorail system. From that station, the Metrorail rider can complete the trip by walking, riding Metrobus, or using the D/C system to arrive at the final destination. The Metrobus trips that enter the downtown area are assigned directly to the transit network on the basis of the minimum travel path. The D/C system will receive riders from these Metrobus trips only if the minimum travel path uses the system.

The internal trip market focuses on trips made by employees and others after they are in the study area. The internal market segment is separated into two categories: workplace-based trips and non-workplace-based trips. Workplace-based trips are made by employees within the study area, such as trips for lunch or shopping. Non-workplace-based trips include other trips in the downtown area that are not related to the workplace of the tripmaker.

The model directly estimates trip generation and distribution as well as modal split for the internal trip market segment. For workplace-based trips, the trip generation (including a no-trip option) and distribution are functions of the number of employees at the origin and number of trip attractions at all destinations. For non-workplace-based trips, generation and distribution are related to the total attractions within the study area. Both workplace-based and non-workplace-based markets have four modes available for making the trip. These modes are automobile, the regional transit system, the D/C system, and walking.

The demand estimation process was developed to predict the impacts of both potential markets. It was determined that the model used for the previous Miami study (2) should be adopted and updated for the EIS study. The outline of the adopted model structure is shown in Figure 1.

### Study Area and Networks

The study area defined for the Miami Metromover EIS Study comprises the Miami CBD and the areas immediately adjacent to the CBD, referred to as the Expanded CBD area. As shown in Figure 2, this area is directly affected by the Metromover system. The study area has I-95 as its western border and includes the community of Brickell, south of the CBD. The study area north of the CBD includes the Omni Shopping Complex and surrounding developments. Biscayne Bay forms the eastern edge of the study area. The study area was divided into 101 internal zones. In addition, 18 external zones were added to represent the remaining Miami region. The external zones represent entry points for both automobile and transit trips to the study area.

After the internal zones were defined, zonal data required for the model were developed for each of the zones. Variables included in the zonal data are parking costs and capacity, employment by classification, and the zone size in acres. Study area employment data for the years 1986 and 2000 are summarized in Table 1.

The next step in describing the study area was the development of the transportation networks. Each travel mode within the study area has a separate network coded to represent the travel characteristics associated with that mode. The networks are designed solely for the segment of the trip within the study area. UMTA's Urban Transportation Planning Systems (UTPS) package was utilized to simulate these networks.

Step 1. The street and highway network was developed by using the HNET and UROAD programs for the morning peak period and the midday period, separately.

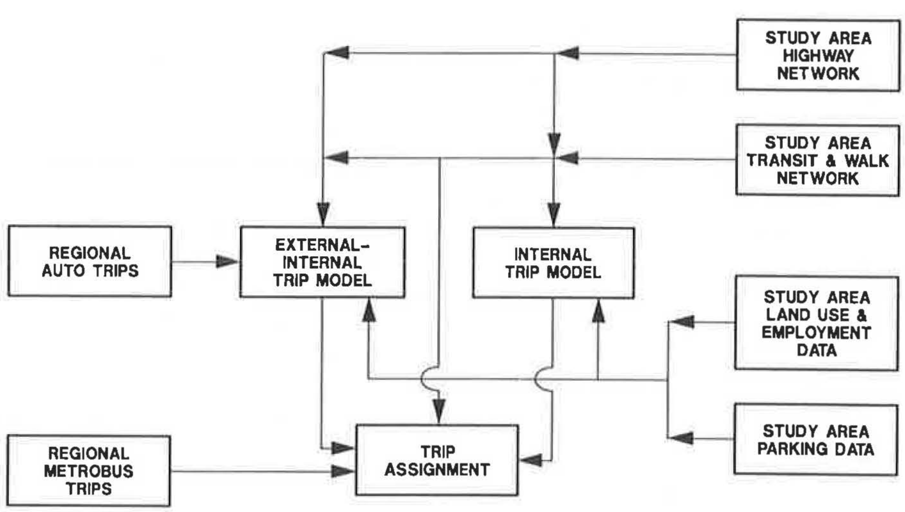


**FIGURE 1 Metromover demand estimation procedure.**

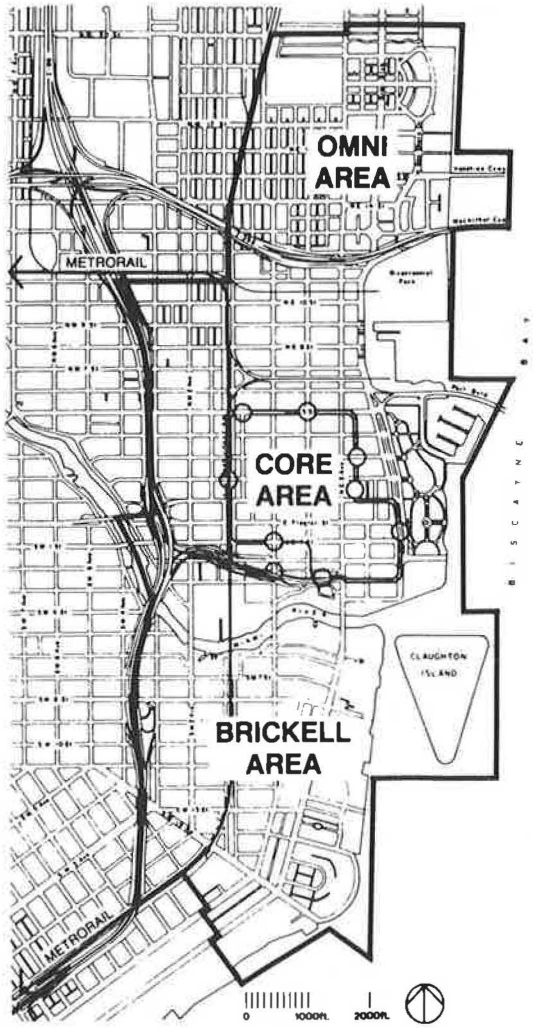


**FIGURE 2 Study area with existing loop component of Metromover system, No-Build Alternative.**

Step 2. Metrobus and Metrorail networks were developed individually for both the morning peak and midday periods. The congested highway time in the morning peak was read by the INET program, and regional transit time was then calculated on the basis of highway speed. The programs UPATH and UPSUM were used to conduct the path search and produce the travel time matrix. The time calculation was performed in a similar manner for the midday regional transit network, except that the uncongested highway travel times were used as input to INET. The D/C network also was developed for both the morning peak and midday periods.

Step 3. A morning peak transit network was developed to include all transit modes, regional transits, and D/C systems for use in assigning the Metrobus trips from the Metro-Dade Regional Model.

Step 4. The walk network was developed by using the optional nontransit links as input to INET. The nontransit links were developed from the highway network, excluding only those links that are freeways or ramps. The walk network has speed coded at 2.5 mph and is assumed to be constant throughout the day. UPATH and UPSUM were used for path searching and producing the travel time matrix.

TABLE 1 ZONAL DATA SUMMARY

| | 1986 | 2000 |
|---|---|---|
| Developed acreage | 1,167.7 | 1,214.1 |
| Employment | | |
| Office | 44,559 | 79,204 |
| Retail | 16,036 | 20,048 |
| Service and institutional | 26,778 | 32,856 |
| Wholesale and manufacturing | 16,099 | 16,464 |
| Others | 6,196 | 6,239 |
| Total | 109,668 | 154,811 |

## External-Internal Trip Model

The first step of the external-internal trip model distributes the automobile and Metrorail trips entering the study area to parking lots and rail stations from external zones. This develops an intermediate trip table among the internal study area zones that represents the last segment of a external-internal trip. This segment consists of the trip from the parking lot or rail station to the final destination.

The second step of the external-internal model provides the mode split to the walk mode, the regional transit mode, and the D/C system mode for these trips between the parking lot or rail station and their final destination. The validated mode choice model logit equation utility coefficients and the parking location model and station location model logit equation utility coefficients are shown in Tables 2 to 5, along with the original coefficients.

TABLE 2 MODE CHOICE MODEL FOR THE EXTERNAL-INTERNAL TRIP (PARKING LOT TO FINAL DESTINATION)

| Utility | Variable | Validated Model | UMTA Model |
|---|---|---|---|
| *U* (Walk) | Constant | +4.7180 | +2.2900 |
| | Walk time | −0.0637 | −0.0979 |
| | Uphill grade | −1.4610 | −1.4610 |
| *U* (Regional transit) | Constant | −1.6470 | +0.2050 |
| | Transit time | −0.0637 | −0.0979 |
| | Transit fare | −0.0287 | −0.0095 |
| *U* (D/C system) | Constant | None | None |
| | Circulator time | −0.0637 | −0.0979 |
| | Circulator fare | −0.0287 | −0.0095 |

NOTE: Logsum = ln{exp[$U$ (Walk)] + exp[$U$ (Regional transit)] + exp[$U$ (D/C)]}.

As described previously, Metrobus trips that enter the downtown area are assigned directly to the transit network on the basis of the minimum travel paths. For these trips, the D/C system is assigned trips only if the minimum travel path uses the system.

## Internal Trip Model

The internal trip model performs trip generation, distribution, and modal split in one step. As stated before, for the workplace-based trips, generation and distribution (including a no-trip option) are a function of the origin zone employment and of the calculated attractions to all possible destinations. Non-workplace-based trip generation and distribution are controlled by the total attractions calculated for every zone. These attractions

TABLE 3 PARKING LOCATION MODEL

| Variable | Validated Model | UMTA Model |
|---|---|---|
| Auto cost | −0.0485 | −0.0161 |
| Walk distance | −9.175 | −9.1750 |
| Ln (parking capacity) | +1.0 | +1.0 |
| Logsum | +1.0 | +1.0 |
| Auto travel time | −0.1077 | −0.1655 |

NOTE: Utility = $U$ (Parking zone).

TABLE 4 MODE CHOICE MODEL FOR THE EXTERNAL-INTERNAL TRIP (METRORAIL STATION TO FINAL DESTINATION)

| Utility | Variable | Validated Model | UMTA Model |
|---|---|---|---|
| $U$ (Walk) | Constant | −1.2900 | +2.2900 |
| | Walk time | −0.0637 | −0.0979 |
| | Uphill grade | −1.4610 | −1.4610 |
| $U$ (Regional transit) | Constant | −3.0620 | +0.2050 |
| | Transit time | −0.0637 | −0.0979 |
| | Transit fare | −0.0287 | −0.0095 |
| $U$ (D/C system) | Constant | None | None |
| | Circulator time | −0.0637 | −0.0979 |
| | Circulator fare | −0.0287 | −0.0095 |

NOTE: Logsum = ln{exp[$U$ (Walk)] + exp[$U$ (Regional transit)] + exp[$U$ (D/C)]}.

TABLE 5 METRORAIL STATION LOCATION MODEL

| Variable | Validated Model | UMTA Model |
|---|---|---|
| Walk distance | −9.175 | Not used |
| Logsum | +1.0 | |
| Rail travel time | −0.1077 | |

NOTE: Utility = $U$ (Station zone).

are converted to productions and distributed to all destinations on every available mode. Validated internal trip model logit equation utility coefficients are shown in Tables 6 and 7, along with original coefficients.

### Trip Assignments

The external-internal model produces daily estimates of walk trips, regional transit trips, and D/C system trips in a productions and attractions (P&A) format. For the purpose of this study, the assignment focuses on those trips that actually use the D/C system. To get the morning peak hour and midday 1-hr assignments for the external-internal market, the daily D/C system trips are factored to obtain morning peak hour and midday 1-hr trips in origin and destination (O&D) format prior to trip assignment. In addition, the daily internal trips are factored by using observed hourly percentages from the Miami Downtown Survey (*3*) to create values for the internal trip market during the morning peak hour and midday 1 hr. The trips from these two markets are then combined and assigned to the D/C system network.

TABLE 6 WORKPLACE-BASED TRIP MODEL

| Utility | Variable | Validated Model | UMTA Model |
|---|---|---|---|
| $U$ (No trips) | Constant | +4.9816 | +9.294 |
| | Origin employee density | +0.0008552 | +0.0008552 |
| $U$ (Walk) | Constant | +5.036 | +3.034 |
| | Walk time | −0.0598 | −0.0919 |
| | Uphill grade | −1.52 | −1.52 |
| | Trip distance | −3.0 | −3.0 |
| | Trip attraction density | +0.00767 | +0.00767 |
| | Ln (zonal area) | (not used) | +1.0 |
| $U$ (Regional transit) | Constant | +2.802 | +2.90 |
| | Transit time | −0.0598 | −0.0919 |
| | Transit fare | −0.0412 | −0.00896 |
| | Trip distance | −4.2 | −4.2 |
| | Trip attraction density | +0.00767 | +0.00767 |
| | Ln (zonal area) | | +1.0 |
| $U$ (D/C system) | Constant | −0.054 | −0.810 |
| | Circulator time | −0.0598 | −0.0919 |
| | Circulator fare | −0.0412 | −0.00896 |
| | Trip attraction density | +0.00767 | +0.00767 |
| | Ln (zonal area) | | +1.0 |
| $U$ (Automobile) | Auto time | −0.0598 | −0.0919 |
| | Auto operating cost | −0.0412 | −0.00896 |
| | Hourly parking cost | −0.0412 | −0.00896 |
| | Trip attraction density | +0.00767 | +0.00767 |
| | Ln (zonal area) | | +1.0 |

TABLE 7 NON-WORKPLACE-BASED TRIP MODEL

| Utility | Variable | Value |
|---|---|---|
| $U$ (Walk) | Constant | +3.824 |
| | Walk time | −0.0581 |
| | Uphill grade | −0.540 |
| | Trip distance | −3.0 |
| | Trip attraction density | +0.00378 |
| $U$ (Regional transit) | Constant | +1.011 |
| | Transit time | −0.0581 |
| | Transit fare | −0.0428 |
| | Trip distance | −4.2 |
| | Trip attraction density | +0.00378 |
| $U$ (D/C system) | Constant | −1.038 |
| | Circulator time | −0.0581 |
| | Circulator fare | −0.0428 |
| | Trip attraction density | +0.00378 |
| $U$ (Automobile) | Auto time | −0.0581 |
| | Auto operating cost | −0.0428 |
| | Hourly parking cost | −0.0428 |
| | Trip distance | −0.113 |
| | Trip attraction density | +0.00378 |
| Non-workplace-based trip attraction | Office floor area | +0.23 |
| | Retail floor area | +1.09 |
| | Service floor area | +0.28 |
| | Manufacturing floor area | +0.058 |

## MODEL VALIDATION

A thorough review of the original model and the previous Miami model was performed before the final model validation work was performed. The following material summarizes recommendations made by the technical review committee.

First, external-internal trips, including those by Metrorail users and Metrobus users, should be estimated in two steps on the basis of the original model. The trip table from bus stop or rail station to final destination should be obtained. The original model assumes that the trip table should be obtained from the previous study and performs a modal split by utilizing a recommended logit equation. It was determined, however, that a rail station location model similar to the parking location model should be developed to create a rail-station-to-final destination trip table that is subject to the modal split. It also was determined that the external-internal bus users should be assigned directly to the transit network on the basis of the minimum travel paths, as discussed in the previous section. This way, regional transit users will have choices for their disembarking locations on the basis of alternatives tested.

It was determined that the natural log of total zonal acres should be eliminated as a variable in the internal trip models for the workplace-based trips and the non-workplace-based trips. The study area consists of zones of unequal size and diverse land development. Some zones are relatively empty, and there are many large surface parking lots. The use of land area in this respect has a distorting effect, placing unreasonable quantities of trips in zones with little or no activity.

TABLE 8 METROMOVER DEMAND MODEL VALIDATION SUMMARY: 1986 METROMOVER DAILY PATRONAGE

| | Validation Against Free Fare System | | Validation Against 25-cent Fare System | |
|---|---|---|---|---|
| Trip Category | Observed | Estimated | Observed | Estimated |
| Transfers between Metrorail and Metromover | 5,724 | 5,591 | 5,724 | 5,591 |
| Others | 6,671 | 6,138 | 3,704 | 3,538 |
| Total | 12,395 | 11,729 | 9,428 | 9,129 |

Time and cost coefficients in the utility equations were reviewed, and it was judged that the model is not sensitive to cost. This issue should be examined in the final model validation process.

Finally, mode-specific constants should be updated on the basis of actual Metromover patronage rather than by validation against the downtown circulator bus and updating of a mode-specific constant for the Metromover that utilizes "image factor," as recommended in the original model.

The model validation procedure was designed to incorporate these recommendations and to check the reasonableness of each of the modeling steps. The results of each step were summarized by trip market to aid in the validation process.

The external-internal trip input from the regional model was summarized for each travel mode. The numbers of automobile and Metrobus external-internal trips by corridor were compared with traffic counts and with transit survey data, respectively. Metrorail trips entering the study area were compared with actual data separately for the three stations in the Expanded CBD area, emphasizing the daily "ons" and "offs" at each rail station. Within the study area, the travel patterns for each external-internal trip market were reviewed in detail; the review included selected paths from zones in the study area. In addition, average trip length, travel time, and the number of trips for each of the competing modes were examined to ensure that all networks within the study area were reasonable.

The internal trips were validated on the basis of the results of Miami Downtown Survey (*3*) for the workplace-based and non-workplace-based markets. These markets were reviewed with emphasis on the total trips generated and the mode split percentages. Again, selected paths from zones in the study area were checked for reasonableness.

The study area zones were aggregated into 11 districts to check the reasonableness of trip length and the movement by mode and by market segment for the trips within the study area.

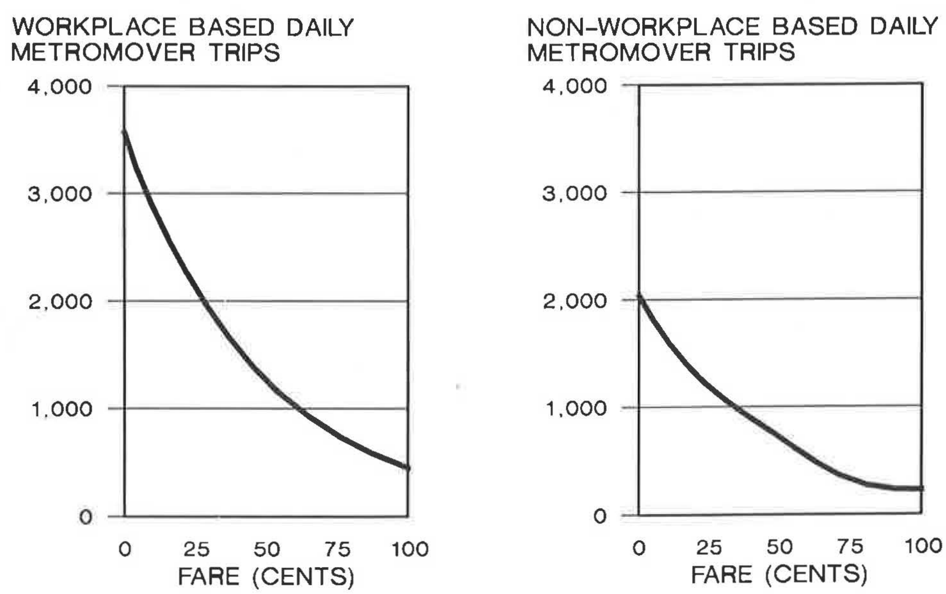


**FIGURE 3 Metromover mode choice model sensitivity to fare (year 1986, existing system).**


**FIGURE 4 Proposed Metromover alignment, Build Alternative.**

Finally, estimated Metromover system patronage was checked against observed 1986 Metromover system patronage. Several iterations were required to adjust parameters until the model provided results that satisfactorily matched observed Metromover ridership patterns for both the free fare system and the 25-cent fare system. Metromover was free during its opening period from April to June 1986. Since then, a 25-cent fare has been charged except for transfers from Metrorail to Metromover. The set of validated model equations is presented in Tables 2 to 7.

A comparison of observed and estimated Metromover riderships is given in Table 8. The differences were judged insignificant for both the free fare system and the 25-cent fare system, as indicated in Table 8. Additional fare sensitivity analysis for the internal trips was performed, and results are shown in Figure 3. Both workplace-based and non-workplace-based trips show approximately the same elasticities. Model validation results, including fare sensitivity analysis, were presented to the technical review committee, including representatives from UMTA and MDTA, for approval. The validated model chain was approved by the technical review committee and was then applied to project future Metromover demands for both the No-Build and Build alternatives.

TABLE 9 DAILY TOTAL TRIPS BY MARKET SEGMENT WITHIN THE EXPANDED CBD FOR THE YEAR 2000

| Market Segment | No-Build | Build |
|---|---|---|
| Internal Trips | | |
| Workplace-based trips | 377,316 | 377,896 |
| Non-workplace-based trips | 162,900 | 162,900 |
| Total | 540,216 | 540,796 |
| External-Internal Trips | | |
| Trips to and from parking lot | 479,418 | 477,955 |
| Trips to and from Metrorail | 23,602 | 25,466 |
| Trips to and from Metrobus | 36,820 | 36,419 |
| Total | 539,840 | 539,840 |
| Total trips | 1,080,056 | 1,080,636 |

NOTE: Includes all trips by automobile, walking, and transit within the expanded CBD.

TABLE 10 DAILY METROMOVER TRIPS BY MARKET SEGMENT FOR THE YEAR 2000

| Market Segment | No-Build | Build |
|---|---|---|
| Internal Trips | | |
| Workplace-based trips | 3,252 | 5,942 |
| Non-workplace-based trips | 1,650 | 3,117 |
| Total | 4,902 | 9,059 |
| External-Internal Trips | | |
| Trips to and from parking lot | 335 | 1,099 |
| Trips to and from Metrorail | 9,682 | 14,909 |
| Trips to and from Metrobus | 840 | 18,222 |
| Total | 10,857 | 34,230 |
| Total trips | 15,759 | 43,289 |

## FUTURE METROMOVER DEMANDS

Two alternatives, No-Build and Build, were tested for the EIS process. The No-Build Alternative consists of Metrorail, the existing Metromover loop (Figure 2), and the existing coordinated bus services. This combined Metromover/Metrobus transit system provides service to the entire Expanded CBD. The Build Alternative consists of the Metrorail System, the existing Metromover loop, the Omni Leg (1.4 mi) and the Brickell Leg (1.1 mi), as shown in Figure 4. The Metrobus System is consolidated to provide an extensive, coordinated feeder network. The Metromover patronage forecasts for both alternatives were generated by the validated model discussed in the previous section.

The total number of trips in the Expanded CBD by all travel modes for all potential market segments is shown in Table 9. Both alternatives generate approximately the same number of trips (1.08 million). Of these trips, the number of persons who use the Metromover System for part of their trip is shown in Table 10. By comparing these two tables, it can be seen that the percentage of total trips using the Metromover System increases from 1.5 percent for the No-Build Alternative to 4.0 percent for the Build Alternative.

## CONCLUSIONS

The use of the validated Miami Downtown People Mover model chain for predicting downtown people mover demand has proved to be valuable for analyzing alternatives for the EIS project. The results were explicable and acceptable to the technical review committee, including representatives from UMTA and MDTA. However, in the process of validation and applications of the model chain, it was recognized that the current Metromover Model can be enhanced. The following are summaries of basic recommendations on model structure.

*Recommendation 1.* The regional model should have a capability to handle the external-internal trip markets of Metromover demand, including Metrorail, Metrobus, and automobile users. To accomplish this, network and path-building procedures should be thoroughly reviewed, as should other regional model issues. A parking location concept also should be incorporated.

*Recommendation 2.* Internal trip markets, including workplace-based trips and non-workplace-based trips, may be analyzed separately from the regional model chain. Further categorization of the internal trip market (with and without automobile accessibility, for example) should be carefully examined.

*Recommendation 3.* The current Metromover model accomplishes trip generation, distribution, and modal split in one step for the internal trip market. Although there are benefits to the structure, particularly in estimating induced trips, it makes the calibration and validation process more complex. Furthermore, the impacts of individual traditional model steps are difficult to isolate. The advantages and disadvantages of each structure should be evaluated before selecting a modeling procedure for internal trips.

*Recommendation 4.* Special trip generators that have trip generation characteristics that are significantly different from the average rates for the four employment and land use categories should be treated differently for the internal trip market. The land use categories currently used in the model are office, retail, service and institution, and wholesale and manufacturing. The model chain should be able to accommodate special generators so that more accurate station loadings and link volumes can be obtained. Examples of special trip generators are shopping centers, large department stores, amusement parks, and colleges.

These recommended enhancements will improve the current model chain; however, including the enhancements requires a significant amount of work. Detailed evaluation of each recommendation, including data-gathering efforts, should be made before any modifications are included in the current model chain.

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# Traffic Modeling Techniques for the Developing World: Case Studies

R. S. TIMBERLAKE

**Traffic models have been used for transportation planning in the Western World for more than 30 years. Recently, attempts have been made to adapt these techniques, which generally originated in developed countries, to suit the needs of the developing world. In adapting the original models, it has usually been necessary to change them, sometimes considerably. The reasons why Western-type traffic models may not be applicable to the developing world are examined. Case studies of rural and urban environments in the Yemen Arab Republic, Sudan, Qatar, and Oman are used as examples, and suggestions are made for changing the Western-type models to better suit developing nations.**

Traffic models have been used for transport planning in the Western World for more than 30 years. During the past 15 years or so, attempts have been made to adapt these techniques, which generally originated in developed countries, to suit the needs of the developing world (*1–5*).

In adapting the original models, it has often been found necessary to develop new formulations for the models or to change the explanatory variables that they employ. There are doubtlessly many reasons why Western-type traffic models have not been found applicable in the developing country environment, but some of the major ones are as follows:

- It is difficult to obtain the required statistical data.
- By definition, less-developed countries start from a low base, and growth is therefore often much more rapid.
- Because world conditions have changed considerably since developed countries were in a similar transport position, today's developing countries are unlikely to follow the same growth pattern as the developed world.
- Ethnic, political, and environmental differences produce different transport needs and behavior characteristics.

In view of these factors, it has generally been found necessary to tailor existing Western technology to suit individual conditions in each developing country. This is not to say that the Western technology has no validity for such countries but simply that this validity must be established rather than assumed for each individual situation.

## BACKGROUND STATISTICAL REFERENCE

It is perhaps desirable to start by giving a global numerical dimension to the Third World transport problem. Since 1950, the world's population has more than doubled, from 2.5 billion to over 5.0 billion. The population increase has been faster where income is low and has been concentrated in developing countries. Of the 1986 world population increase of some 80 million plus, more than 70 million is estimated to have been in developing countries. These nations now contain over three-quarters of the global population.

At present, the population growth rate in developing countries averages some 3 percent per year. This implies that, unchecked, the population of these countries would more than quadruple in the next 50 years. Even if couples in these countries have fewer children, there is still a certain population momentum due to the "baby bulge." This phenomenon is the result of high fertility and falling mortality some 20 years ago. The offspring of the baby bulge have now reached child-bearing age. Therefore, to use World Bank estimates (*6*), the world population will continue to rise at 80 million per year for some years to come.

This rapid population growth has also been associated with rapid urban expansion, which causes associated economic and social problems in the developing world. Between 1950 and 1980 the number of urban dwellers in developing countries has been growing at a rate of some 4.1 percent a year. By the year 2000, Mexico City will probably be the world's largest city, followed by Brazil's São Paulo. In 1950, São Paulo was smaller than Manchester, England; Detroit, Michigan; or Naples, Italy. London, the world's largest city at the beginning of the 20th century, will not be ranked in the 25 largest cities at the end of the century.

In 1982, there were 684 vehicles per 1,000 people in the United States, whereas the same figures in Great Britain, Chile, and Jordan were 320, 75, and 63, respectively. In the United States in 1984 the automobile population increased from 126.15 million to 127.87 million, or by less than 1 percent, whereas in Venezuela in the same period the automobile fleet increased from 1.96 million to 2.12 million, or by over 8 percent. In South Korea, the automobile fleet increased from 0.38 million to 0.46 million, representing a staggering annual increase of 22 percent (*7*).

These rates of growth in urbanization and the accompanying demand for transport and transport infrastructure that have been and are being experienced in the developing world far exceed those that have been experienced in the developed world. Also, when projected forward, these rates take us into ranges (such as the 20-million-person city) previously unknown. This poses a double dilemma for those responsible for preparing plans and designs to accommodate such growth. First, the explosion in growth implies that historic records cannot be used to project the future; second, when

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projections are made for the future, the magnitude of the problem is beyond all experience elsewhere in the world.

## DESCRIPTIONS OF TYPICAL PROBLEMS

Described in this paper are some examples of recent Third World transport studies in which the author was involved and in which the standard traffic modeling approach needed to be adapted. The problems tend to differ for urban- and rural-type studies, and two typical examples of each case are cited in the paper.

### Rural Studies

In the environment of the developing country, certain factors dictate several typical differences of approach. First, many of these nations have primitive track road systems that generally have not been engineered and that are poorly indicated on existing plans. These tracks often provide a multiplicity of routes that are impossible to identify or survey over a wide area. Second, these nations may have embryonic main road networks, which means that many existing journeys are made on primitive roads with very low average running speeds and considerable journey inconvenience. Extending the main road system in such cases may dramatically change accessibilities and lead to major changes in trip distribution and very high levels of traffic generation. Finally, there may be delayed road network development, in which high levels of latent demand for transport have built up. Original networks, often built to suit colonial needs, do not match existing population distributions and present economic activities.

### Urban Studies

The urban environment in the developing world is often considerably different from that of larger western towns and cities. In particular, developing urban situations generally (a) are growing much faster than Western cities, (b) have mixed ethnic compositions of widely variant socioeconomic composition, and (c) have narrow street central cores constructed prior to the age of mechanized transport.

## RURAL STUDY EXAMPLES

### The Yemen Arab Republic Highway Master Plan

*Background*

To understand the nature of the problem of producing a national traffic model for the Yemen Arab Republic (YAR), it is necessary to understand the existing population distribution characteristics and the stage of development of the highway network of the country. The population is very widely dispersed in small settlements, as indicated in Table 1.

People in small settlements (i.e., the bulk of the population) are generally served by very minor tracks. These tracks are often of a very low standard and are only passable (with difficulty) by jeep-type vehicles. This network was estimated to comprise about 30 000 km. The existing paved network comprised some 2 000 km, together with about 1 000 km of gravel roads. The test network for the highway master plan (*8*) was therefore defined by function, rather than by existing traffic demand, and roads down to the interdistrict level were considered. The administrative hierarchy consisted of the nation, 11 governorates, 171 districts, and about 50,000 villages. Each district had a nominated district center (local administrative center). The test network connected all district centers to the existing paved network.

TABLE 1 YAR POPULATION DISTRIBUTION

| Size of Settlement | No. of Settlements | Percentage of YAR Total Population |
|---|---|---|
| 100,000+ | 3 | 8.2 |
| 25,000–99,999 | 2 | 1.2 |
| 10,000–24,999 | 10 | 2.0 |
| 5,000–4,999 | 15 | 1.7 |
| 1,000–4,999 | 406 | 10.0 |
| 500–999 | 1,300 | 15.2 |
| 250–499 | 4,600 | 12.6 |
| Under 250 | 46,400 | 49.1 |
| Total | 52,736 | 100.0 |

The problem was to estimate the probable transport demand on each link of the test network at various future times. Even for the existing situation, the true traffic volumes for all movements could not be surveyed. The tracks form a complex network, and often several alternative routes exist. However, the paved and gravel road system was clearly defined, and for this, accurate traffic movement information could be collected by origin-destination interview surveys.

The Master Plan was required to take account of the future changes that were proposed for the economy. The main components of these changes concerned increases in agriculture, industrial activity, exploitation of minerals, and formal employment.

*Traffic Model Requirements*

Given the instability of previous traffic trends and the major changes to the economy expected in the future, an analytical but robust analysis was called for. The model would need to reflect both present and projected transport demand for the major population centers and for the rural areas. A large number of schemes and network combinations would need to be tested, and an optimum staging for construction would need to be developed. Therefore a matrix method (representing origin-to-destination movements) was applicable. This method would then permit any test network to be developed and analyzed.

For the purposes of constructing the matrices, the country was divided into 78 zones with two external areas—Saudi Arabia and the People's Democratic Republic of Yemen (PDRY). The zones were selected to be relatively homogeneous in terms of population, terrain type, economic activity, and so on, and to follow existing administrative boundaries. The zones were numbered roughly in order of decreasing population density, so that the large cities and towns on the existing paved network had the lowest numbers. This led to a situation that may be represented graphically as shown in Figure 1.

This situation is not uncommon in transport planning. It is often referred to as the "Top-L" problem, and the matrix is referred to as a partially observed matrix. Partial matrix problems are well known and are often the normal situation in an origin-destination study. Methods for dealing with the classical problem (the partial matrix) have been well researched and are well documented (*9*). However, the problem here is somewhat different from the classic case.

In the case of YAR, the part of the matrix that cannot be well observed represents the bulk of the whole matrix. Also, it represents the bulk of the population, because 76.9 percent live in settlements of less than 5,000 inhabitants. Furthermore, the characteristics of these rural dwellers are quite different from those of the well-observed urban dwellers. However, it would be wrong to presuppose that vehicle ownership and motorized trip rates would be negligible in these small settlements. Early investigations indicated that rural vehicle ownership could be as high as, and in a few cases was higher than, that typically found in the towns. Rural trip rates were also established as not being inconsequential, but trip length distribution had no comparison with urban observations.

These requirements indicated that the problem could not be satisfactorily solved by standard techniques. The problem was such that each zone-to-zone movement (matrix "cell") would need to be modeled specifically. The modeling would need to be based not only on parameters that described each zone but also on the accessibility (time and cost) between each zone pair. The parameters that were available for testing to describe each zone, calculated for the base year and plan horizon years, were as follows:

Gross domestic product, (GDP),
Gross national product (GNP),
Income from government employment,
Income from industrial employment,
Income from agriculture and fisheries,
Agricultural production,
Agricultural consumption,
Industrial production,
Industrial consumption,
Trade out,
Trade in,
Percentage of households owning a vehicle,
Population, and
Population density.

### *Model Formation*

A log-linear direct demand model of trip generation and distribution was selected for the study. This kind of model would be capable of representing the considerable growth of traffic expected to occur in YAR when substantial development of the paved road network is made. Such a model has far fewer parameters than the conventional doubly balanced gravity model and so is more appropriate when the observed trip matrix is rather sparse. Also, in the case of YAR, only six rows and columns could be fully observed and therefore available for a trip end model, whereas it could be shown that 3,676 cells (out of a possible 6,084 internal cells) had been fully observed and were available for the direct demand model fitting. The difficulty for a doubly balanced gravity model lies in the production of trip generation and attraction models that adequately reflect future travel time changes.

A log-linear direct demand model (*10*) makes the logarithm of the number of trips from zone $i$ to zone $j$ ($T_{ij}$) a linear function of the available explanatory variables. Specifically, for one of the models selected (out of some 40 models tested, employing different parameters),

$$\begin{aligned} \ln T_{ij} = 11.3 &- .00872\, d_{ij} - 1.81 \ln d_{ij} \\ &+ .244 (\ln E_i + \ln E_j) \\ &+ .854 (\ln G_i + \ln G_j) \\ &- .782 (\ln H_i + \ln H_j) \\ &- .0238 (\ln P_i + \ln P_j) \end{aligned}$$

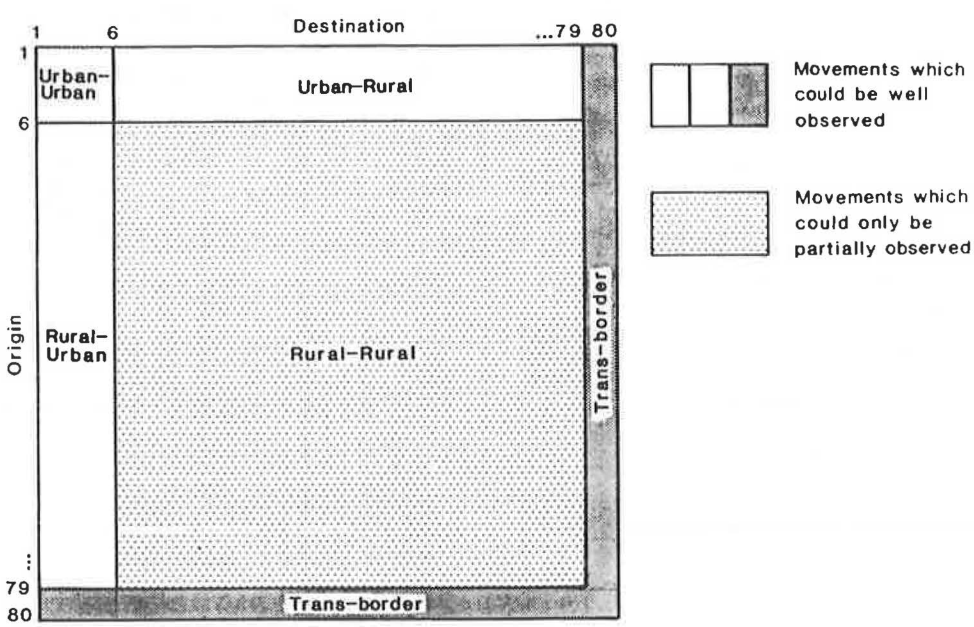


**FIGURE 1 Matrix of origin-to-destination movements for YAR.**

or equally,

$$T_{ij} = E_i^{.244} G_i^{.854} H_i^{-.782} P_i^{-.0238} \times E_j^{.244} G_j^{.854} H_j^{-.782} P_j^{-.0238} \times \exp(11.3 - .00872\, d_{ij} - 1.81 \ln d_{ij})$$

where

$d_{ij}$ = travel time from zone $i$ to zone $j$;
$E_i, E_j$ = population of zone $i, j$;
$G_i, G_j$ = income from government of zone $i, j$;
$H_i, H_j$ = GDP of zone $i, j$; and
$P_i, P_j$ = population density of zone $i, j$.

The model directly predicts the number of trips in a cell, given the fitted coefficients and explanatory variables for the cell. From its second written form, the model value can be seen to be a product of an origin zone factor, a destination zone factor, and a travel time factor, and each factor itself is of product form.

The model may use any transformations of the available explanatory variables. For the selected model, it was found that only travel time deserved a more complicated treatment than merely the logarithm. It was also discovered that the coefficients of corresponding origin and destination zone variables could be made equal with no worsening of the fit.

The direct demand models were fitted by choosing the coefficients to minimize

$$\Phi = 2 \sum_{ij} (T_{ij} - N_{ij} \ln T_{ij} - N_{ij} \ln N_{ij})$$

where $T_{ij}$ is the grossed-up model value, $N_{ij}$ the grossed-up observed value, and the sum is taken over all observed cells. A cell contributes to $\Phi$ an amount that increases as $T_{ij}$ differs from $N_{ij}$. For $T_{ij}$ close to $N_{ij}$, this contribution is close to $T_{ij}$ $(N_{ij}/T_{ij} - 1)^2$, a squared relative error weighted by $T_{ij}$. Thus, $(\Phi/N_{++})^{1/2}$, where $N_{++}$ is the total number of observed trips, is a weighted root mean square relative error.

The effect of using this fitting criterion is that if $Y_{ij}$ is any one of the explanatory variables, the coefficients will be chosen so that

$$\sum_{ij} T_{ij} Y_{ij} = \sum_{ij} N_{ij} Y_{ij}$$

exactly. This fitting measure was chosen because it is the one usually used in doubly balanced gravity model fitting and because as long as a constant and the travel time are included in the model, it ensures that the model values of total trips and total trips multiplied by travel time equal the corresponding observed values.

An alternative fitting criterion is maximum likelihood. The observed trip numbers can very reasonably be described as scaled-up Poisson samples, and maximum likelihood fitting is obtained by weighting each cell's contribution to $\Phi$ by the effective sampling fraction for the cell (the reciprocal of the index of dispersion). This changes the fit from one in grossed-up trip numbers to one in trip counts. The two criteria are the same if the sampling fraction is the same for every cell. Maximum likelihood fitting does not ensure that total grossed-up trips and total travel time are the same for model and observed. When this method was used in a trial fit, it led to a 30 percent error in total trips, which was felt to be unacceptable. It should be noted that the sampling fractions vary by a factor of 10; some cells were highly sampled because of multiple interceptions.

### *Aims of Model Selection*

A great many log-linear models may be determined from a given number of explanatory variables and their transformations. Five rules for helping select a final model are as follows:

- It should fit the data well;
- It should have a sensible interpretation;
- It must be suitable for forecasting;
- The coefficients should not be large; and
- Coefficients of retained variables should be larger than their standard errors of estimate.

The second rule means that variables that would be expected to increase the number of trips should have a positive coefficient. When the model is used for forecasting, it is likely that some of the variables will have larger values than those that occur in the base year data. This applies to population and the economic variables but not to travel time.

The third rule says that the model must behave reasonably when this occurs. The forecast variables will have some error. Because the variance of the linear part of the model will be the sum over the variables of their forecasting variance times the square of their coefficient, large coefficients tend to mean large forecast variance. In particular, the fourth rule means avoiding variables in the model that are similar and have large coefficients of opposite signs.

When these rules were followed, the last two turned out to be automatically satisfied. The "suitable for forecasting" rule had a major effect.

## The Khartoum–Wad Medani Corridor (Sudan) Example

### *Background*

This study involved several levels of traffic investigation, from consideration of transport movements by all modes in the northeast of Sudan through to the study area region and thence to the corridor itself *(11)*. The aspect described here relates to the final level of investigation in which a comparison was made of the options of doubling the existing paved road on the west bank of the Blue Nile or building a new paved road on the east bank.

In passing it may be noted, however, that for the whole area study, a considerably better model fit was obtained by using a direct demand model (as described for YAR) than was obtained with a doubly constrained gravity model. The explanation of this lay in the fact that Khartoum and Port Sudan exhibited entirely different traffic characteristics from the rest of the country and thus could be modeled separately with the direct demand formulation.

The Khartoum–Wad Medani Corridor example is similar to the YAR case in that one of the problems was to estimate future traffic volumes in a situation where interzonal travel times would be considerably altered by the construction of the new paved East Bank road to be studied. However, the situation differs from YAR in that the "with scheme" scenario could be inferred from other available data.

*Approach*

To assist in the quantification of the likely magnitude of generated traffic, an analysis was made of the trip rates by trip purpose, which were established by the consultants' roadside and home interview surveys. For this exercise, zones on the west bank of the Blue Nile and zones on the east bank were examined separately. Zones close to the west bank have generally good accessibility provided by the existing paved road, whereas zones close to the east bank have generally poor accessibility. However, the socioeconomic surveys indicated that households on both sides of the Nile were quite homogeneous in terms of their characteristics.

The analysis indicated, for example, that on average, one trip was made per day to Khartoum or Wad Medani for every 407 people living within a zone on the west bank. For the east bank the corresponding figure was one trip per day for every 842 people, or less than half the trip rate on the west bank. Other zone-to-zone movements were also examined for west and east bank zones, and a similar relationship was found.

If the explanation of the difference in trip rates between the west and east bank zones may be attributed purely to the relative difference in accessibility, which is entirely plausible, then an estimate may be made of the level of generated traffic that would occur if accessibility were equal on both sides of the Blue Nile. Thus, if a paved road also existed on the east bank of the Blue Nile, one might expect existing person trips (i.e., nongoods trips) to more than double. Of course, such a change in trip-making behavior could not be expected to occur instantly. However, it is likely that over a period of time, if equal accessibility occurred on both banks, then trip rates would also stabilize and become equal on both sides of the Blue Nile.

### Summary of Rural Study Problems in Developing Countries

Trip distribution, traffic generation, and traffic growth rates generally require special treatment in rural traffic studies for developing countries. Sometimes these problems may be tackled by adapting the formulation of the traffic model. In this respect a direct demand formulation that combines trip generation and attraction with trip distribution in one process can be more successful than the two-stage trip end and doubly constrained gravity model approach. In other cases, trip rates and trip distributions may be transported from a "with project" analogous case in the country in question to appraise a "without project" case at another location. If this "transportation" of behavior from one location to another is to be attempted, control socioeconomic household data (usually from household interviews) will be needed.

Elasticities between supply and demand are often much greater (a value of 20 is not unthinkable) in the developing world than those established in Western studies. However, the range of values between different locations is also considerable, and a suitable figure generally needs to be established for each individual case.

## URBAN STUDY EXAMPLES

### The Doha Capital Area (Qatar) Study Example

*Background*

As part of a national traffic study, an urban traffic model was created for Doha, the capital of Qatar. The modeling approach followed classical methods and included home interviews and roadside traffic interviews, as well as a large number of time-based volumetric machine counts (*12*).

*Modeling of Vehicle Ownership and Trip Rates*

Several differences in modeling approach were needed for the study, but one particular difference of approach from that applied in Western cities was related to the modeling of vehicle ownership and household trip rates. A standard category analysis approach was employed, but it was found that a complete reformulation of the model was needed to meet local conditions.

Initial statistical analysis of the home interview data indicated that a very low correlation existed between vehicle ownership, trip rates, and household income. In contrast, in Western cities, it is generally found that household income is a dominant variable for these transport parameters. In view of this, a new approach had to be adopted for the category analysis model.

*Trip End Model Formulation*

The first part of the model predicted the distribution of households in each traffic zone among the 30 vehicle availability/family structure categories defined (Table 2). Three steps were involved:

- Predict vehicle availability distribution;
- Predict family structure distribution; and
- Adjust the study area vehicle availability/family structure matrix, until the row and column totals satisfy these constraints (Fratar Method).

TABLE 2 FAMILY STRUCTURE AND VEHICLE AVAILABILITY CATEGORIES FOR QATAR

| Family Structure | | | Vehicle Availability | |
|---|---|---|---|---|
| Group | Household Size | Number Employed | Group | No. of Vehicles per Household |
| 1 | 1–4 | 0–2 | 1 | 0 (no vehicle) |
| 2 | 1–4 | 3–4 | 2 | 1 (single vehicle) |
| 3 | 5–8 | 0–4 | 3 | 2 (multiple vehicles) |
| 4 | 5–8 | 5–8 | 4 | 3 (multiple vehicles) |
| 5 | 9+ | 0–4 | 5 | 4+ (multiple vehicles) |
| 6 | 9+ | 5+ | | |

A preliminary investigation of the household interview data showed very little correlation between vehicle availability and household income. Other variables that might explain the variation in vehicle availability between traffic zones were therefore investigated by using regression analysis techniques. The results are shown in Table 3. The most useful variables were those that were able to explain the variation in vehicle availability and were also easy to predict. Ethnic group and dwelling type were chosen as being most appropriate.

The household interview data were used to calculate the average numbers of vehicles per household for each of the 30 ethnic group/dwelling type combinations, as defined in the survey (six ethnic groups, five dwelling types). Inspection of these values showed that the 30 categories could be reduced to six valid combinations. The regrouping was carried out on the basis of similarities of particular categories in terms of average household vehicle availability, the number of households in each category, and the ability to estimate the future household distributions.

TABLE 3 ALTERNATIVE VARIABLES POSSIBLY AFFECTING VEHICLE AVAILABILITY IN QATAR

| Variable | Percentage Variation in Vehicles per Household Explained |
|---|---|
| Ethnic group | 76.8 |
| Occupation of head of household | 57.0 |
| Dwelling type | 51.2 |
| Family structure group | 39.7 |
| Average household income | 1.4 |

For any traffic zone, it is possible to calculate the average number of vehicles per household, given the number of households in each of the selected six household types. About 73 percent of the variation in vehicles per household between traffic zones could be explained in this way.

The probability ($P_n$) of a household being in vehicle availability group $n$ is assumed to be given by the following equations (for any zone $i$):

For vehicle availability group 1 (0 vehicles):

$$P_{0i} = \frac{1}{1 + K_0\,(\beta_i\,C_i)^{N_0}}$$

where

$C_i$ = average number of vehicles per household;
$\beta_i$ = a locational variable dependent on factors such as accessibility; and
$K, N$ = calibrated coefficients.

For vehicle availability groups 3–5 ($n$ = 2, 3, or 4+ vehicles):

$$P_{ni} = 1 - \frac{1}{1 + K_n\,(\beta_i\,C_i)^{N_n}}$$

For vehicle availability group 2 (1 vehicle):

$$P_{1i} = 1 - (P_{0i} + P_{2i} + P_{3i} + P_{4i})$$

Values of $K_0$, $N_0$, $K_2$, $N_2$, $K_3$, $N_3$, $K_4$, $N_4$ were derived from the survey data by variable transformation and multiple linear regression at a zonal level.

## The Oman Capital Area Traffic Model Example

### *Background*

The Capital Area of the Sultanate of Oman is a wide region, covering almost 600 km$^2$ of developable land. The area includes traditional urban settlements such as the old town of Muscat, new town communities, a new central business district, rural village-type settlements, industrial areas, two major seaports, an international airport, and a petroleum plant and refinery.

The past 2 decades have witnessed a rapid and sustained growth in the economy of Oman. This growth has largely stemmed from the utilization of the sultanate's oil and gas reserves and has accelerated with the rise in the world oil prices in the late 1970s and early 1980s. The vehicle fleet increased six-fold between 1976 and 1985, following a four-fold growth in GDP over the same period. The Capital Area has been the main growth pole in the sultanate. Its population has quadrupled in 10 years, from an estimated 56,000 people in 1970 to 226,000 in 1980, and has continued to grow at over 10 percent per annum thereafter.

The objectives of the study (*13, 14*) were first, to develop a strategic traffic model that could be used to test network proposals over short-, medium-, and long-term planning horizons, and second, to establish an efficient road and traffic data collection and processing system.

### *Model Specification*

The terms of reference for the study called for the development and calibration of a strategic traffic model that was to be based on sound data. The modeling methodology had to make maximum use of data that were already available, augmented with data from new traffic surveys. The model had to be simple but robust and capable of making forecasts that reflected the impact of the development of new communities and of new strategic highway links. The methodology also had to indicate how the results of the model could be used to evaluate alternative network configurations and phasing strategies.

No national census had ever been undertaken, and a household interview survey was ruled out. New traffic surveys therefore had to be confined to roadside interviews and traffic counts.

### *Traffic Surveys*

The traffic surveys comprised

- Roadside interviews with a sample of travelers at key locations;
- Bus surveys, including on-board passenger interviews and counts;
- Manual classified counts;
- Automatic traffic counts;
- Journey time surveys;
- Vehicle occupancy counts; and
- Highway network inventory.

To obtain information on the relationship between trip making, vehicle availability, and household characteristics, four additional questions were included in the interview surveys, namely,

- The number of vehicles available to the traveler's household (including vehicles provided by employers), and
- The dwelling type of the traveler's household (i.e., villa, modern house, flat, traditional Omani house, other), as proxy for household income;

in combination with

- Nationality of the traveler, and
- The location of traveler's residence (if not already surveyed, i.e., for non-home-based trips).

The travel and household characteristics obtained from the interviews had to be related to zonal planning data. Planning information was assembled from available records held by various authorities in the sultanate.

The planning data were referenced to the study zoning system. The Capital Area was divided into 121 zones of suitable size, reflecting the local characteristics. The internal zones could be aggregated into 10 sectors for examining broader travel patterns. Areas outside the capital, both within the sultanate and further afield, were grouped into 27 external zones.

### *Modeling Methodology*

The modeling methodology, which was developed on the basis of the model specification, the data availability, and the transport planning needs, was as follows.

First, by using roadside interviews and the "partial matrix" technique, a first estimate of the base year origin-destination trip matrix was obtained.

Second, by using traffic counts and the "matrix estimation from the volume counts" technique (*15*), the unobserved parts of the trip matrix from the first step were adjusted until they reproduced the observed traffic flows.

Third, by using available zonal land use data and the resulting trip ends of the adjusted matrix from the second step, a trip end model was calibrated. This model took into account vehicle availability on the basis of household trip generation rates by mode and purpose.

Fourth, by using a base year network description and the adjusted trip matrix from the second step, a gravity trip distribution model (by mode and purpose) was calibrated.

Finally, by using the trip end model from the third step and trip distribution model from the fourth step, a synthesized base year matrix was obtained. The resulting matrix was assigned to the base year network, and the flows were checked against counts.

## Summary of Typical Urban Study Problems

The two urban study examples cited above illustrate certain typical developing world urban traffic study issues. For example, urban size, vehicle ownership, and transport demand in Third World cities are often growing at a considerably faster rate than has ever been experienced in the West. Basic statistical data (census data) are often not available, and home interview surveys may be socially unacceptable or administratively very difficult. In addition, trip-making behavior and vehicle ownership may follow a very different pattern from those in the West.

The examples show, however, that existing models may be reformulated to match local transport behavior. In addition, for those cases in which obtaining data in a traditional manner (e.g., home interviews) is impractical, the data can sometimes be obtained by other means.

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# Some Issues in Transport Planning for Third World Cities

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**In this paper, the nature of the transport problems facing Third World cities is briefly discussed, aspects of approaches being adopted to address these problems are commented on, and reasons why these approaches presently are not having the desired effects are indicated. In discussion of this last issue, one of the factors identified as a negative influence is the present inadequate integration of transport and urban development actions. It is argued that this problem must be remedied because transport is a service to urban development, and its planning must therefore be responsive to the nature of urban development forces.**

In these last two decades of the 20th century, the cities of the Third World are having to absorb an additional 1 billion people, most of them poor. Almost without exception, these people will be accommodated in cities that are currently typified by chronic shortages in basic services for large sections of their existing population. One of the basic services that is suffering this chronic shortage is transport. Yet along with increasing population and spatial growth, new demands for travel are being generated and must be accommodated in planning. The main tool that the transport planning profession presently has at its disposal in this task is a methodology that evolved in affluence, whereas the typical Third World context is characterized by poverty. This methodology must therefore be sufficiently modified so that it becomes appropriate for use in the Third World. Alternatively, a new methodology could be developed.

The objective of this paper is to briefly discuss the nature of the transport problems facing Third World cities, comment on aspects of approaches being adopted to address these problems, and indicate why these approaches are not having the desired effects.

In the discussion of the last topic, one of the factors identified as a negative influence is the current inadequate integration of transport and urban development actions. It is argued that this problem needs to be remedied because transport serves urban development, and its planning must therefore be responsive to the nature of urban development forces. Only through this approach can the real transport issue of Third World cities—how to minimize the need to travel while still facilitating developmental activities—be adequately addressed.

## THIRD WORLD URBAN TRANSPORT PROBLEMS AND PLANNING

### Third World Realities and the Conventional Planning Process

To the transportation engineer, the key characteristic of the transport problems of Third World cities is chronic traffic congestion, which arises from inadequate road network provision and from misuse and abuse of those roads that are provided. To the transport economist, the dominant feature is the high cost associated with travel within these cities. The cost is high in terms of time and fuel wasted traveling in the chronic traffic congestion and wasted opportunities for productive activities, and the cost of providing and using transport services is also high.

From the sociological and political perspectives, however, the transport problems of Third World cities would most likely be seen in terms of the tendency of transport planning actions to reinforce existing inequalities through insufficient consideration of and attention to the needs of the urban poor. The emphasis that is invariably given to construction of primary roads over secondary and local roads, the absence of bus priority measures on such roads, the notable underinvestment in public transport vehicles, and so on, are symptomatic of this neglect. As a consequence of these actions, urban transport issues have become highly visible at the political level and may become a focal point for political action.

The political scientist is also likely to identify urban transport problems of the Third World as being characterized by imposition: the methodology applied, its main practitioners, its technology and standards, and (quite importantly) its funding sources and conditionalities are dependent on external factors. It should not be surprising, therefore, that the Third World urban transport situation seems to be worsening rather than improving. The current characteristics of the situation are as follows:

- Inadequate technical and material resources;
- High incidence of inadequate attention to and provision for mobility needs in both planned and unplanned settlements;
- Inadequate awareness of the transport implications of land use developments;
- Absence of long-term strategic perspectives in transport actions, resulting in reactive rather than prescriptive planning;
- Dominance by the highway engineering view of the problem, resulting in too much concern about increased system efficiency and capacity without adequate consideration of who suffers and who benefits from changes in these performance measures;
- Increasing journey distances and travel time, with the latter factor often due to transport system deficiencies;
- Application of urban and road design standards often out of tune with social, cultural, and economic realities;
- Lack of provision for freight movement, one of the key visible outputs of national and urban development;
- A high accident rate, resulting from misuse and abuse of an already deficient infrastructure;

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- Application of technical criteria that insufficiently consider the developmental context in which they are being applied and the basic service role of transport in the fulfillment of developmental goals;
- Highest aggregate rate of growth in demand for mobility from those least able to afford to pay for it;
- Setting of inappropriate goals for public agencies that operate transport services, resulting in their inability to effectively meet existing demand or plan for the future;
- The neglect of nonmotorized modes of travel;
- Perception of informal motorized public transport as an undesirable element rather than as a valuable part of the urban scene;
- Inadequate and often inappropriately educated transport professionals incapable of viewing their actions in a wider context;
- Inadequate institutional frameworks for plan formulation and implementation at the different levels of government;
- Ineffectiveness of traffic and land use control and regulatory instruments, where they exist at all;
- Lack of a national awareness of urban transport needs;
- A seeming impotence in planning actions, which has a demoralizing effect on transport professionals, among others;
- Insufficient provision of road space, especially secondary roads; and
- An inadequate information base for planning action.

Of course, not all of these characteristics will be found in every Third World city, and neither will they be equally significant in each location. As a generalization, however, they describe the present transport realities of these cities.

According to the recent World Bank sector policy paper on urban transport (*1*), the present transport situation of Third World cities is the result of the following factors:

- Large increases in urban population, leading to a proportional increase in transport trips;
- Spread of urban areas, incurring the need to expand road networks, undertake longer journeys, and consume more fuel;
- Greater availability of motorized transport, resulting in more motorized trips and increases in fuel consumption;
- Increases in household income, creating a greater propensity for travel and a marked increase in car ownership, with a consequent demand for more road capacity; and
- Increases in commercial and industrial activity, leading to increased volumes of service vehicles and freight traffic.

Cumulatively, these factors are believed to have caused widespread traffic congestion, greatly increased transport costs (especially among those with low incomes), and serious loss of productivity in commerce and industry. In parallel with these trends, and perhaps serving to compound their adverse effects, is the seeming inability of the institutions responsible for transport to fulfill their obligations.

As a description of the present transport realities of Third World cities, the analysis just presented is difficult to dispute. However, as argued elsewhere (*2*), these realities are also the result of the assumptions and perceptions underlying the conventional urban transport planning approaches hitherto applied to the provision of transport facilities and services for these cities:

- The Third World urban transport problem is that of how to overcome motorized traffic congestion.
- Rapid growth in car ownership is inevitable.
- Informal public transport is unimportant.
- Benefits are best derived by improving the operational efficiency of urban transport systems.
- The variables affecting travel demand will not experience marked unexpected changes.
- Urban transport problems are essentially the same worldwide.

These assumptions do not take into account the typical developmental features of Third World cities:

- Fast rate of population and spatial growth;
- Low and unstable revenue base;
- Low and uneven income levels among the inhabitants;
- High rate of growth in vehicle ownership among a small but significant minority, while the majority are dependent on nonmotorized modes of travel;
- Acute deficiencies in the provision of basic infrastructures and services;
- Absence of effective frameworks for urban management;
- Misplaced developmental priorities; and
- The inability to plan for and control the future.

When the conventional planning assumptions are interfaced with these typical Third World developmental features, it is apparent that most if not all are inappropriate.

The primary Third World urban transport problem cannot be that of overcoming motorized traffic congestion when most of the population cannot afford to use such vehicles. The motorization level of West African cities (25–60 per 1,000 population) and the declining trend of these levels is not typical of other Third World cities (*3*).

Rapid growth in car ownership is probably inevitable only among a small proportion of the population. The ability of this group to realize their aspiration, however, is heavily constrained by foreign exchange scarcity. Table 1 shows that the Gross National Product (GNP) per capita in a randomly selected list of 16 Third World cities is only about 1/13th the price of an economy car. This compares with a ratio of 0.7 for the four industrialized cities listed.

Informal public transport (an unregulated and largely illegal form of public transport typified by single-owner operation) cannot be unimportant when, in many cases, it is the only motorized mode of travel accessible (in both spatial and monetary terms) to the majority of the population. The importance of this mode becomes even clearer when it is considered that, apart from its service role, informal public transport is also a source of employment, income, or both for large sections of the population.

Although benefits can certainly be derived by improving the operational efficiency of urban transport systems, it is doubtful if the criteria often used as indicators of efficiency, such as vehicles per hour, travel time and speed, and so on, are appropriate in a context that is actually typified by an inability to travel. The issue being raised here relates to the objective criterion or raison d'être that underlies operational improvement measures. For example, use of such measures as people

TABLE 1 URBAN TRANSPORT DATA FOR SOME SELECTED CITIES (*1*)

| City | Population | | GNP per Capita, 1980 (U.S. $) | Automobiles per 1,000 Population, 1980 | Number of Automobiles: Annual Growth Rate 1970–1980 (%) | Market Price of Economy Automobile, 1983 (U.S. $) | Economy Automobile Price, Ratio to GNP per Capita |
|---|---|---|---|---|---|---|---|
| | 1980 (thousands) | Annual Growth Rate 1970–1980 (%) | | | | | |
| Third World Cities | | | | | | | |
| Abidjan | 1,715 | 11.0 | 1,150 | 50 | 10.0 | 6,560 | 5.7 |
| Accra | 1,447 | 6.7 | 420 | 19 | – | 6,000 | 14.3 |
| Bangkok | 5,154 | 9.1 | 670 | 71 | 7.9 | 10,870 | 16.2 |
| Bogota | 4,254 | 7.1 | 1,180 | 42 | 7.8 | 6,075 | 5.1 |
| Bombay | 8,500 | 3.7 | 240 | 21 | 6.1 | 7,327 | 30.5 |
| Cairo | 7,464 | 3.1 | 580 | 32 | 17.0 | 10,002 | 17.2 |
| Harare | 670 | 5.2 | 630 | 160 | 3.0 | – | – |
| Jakarta | 6,700 | 4.0 | 430 | 33 | 9.8 | 18,697 | 43.5 |
| Karachi | 5,200 | 5.2 | 300 | 35 | 8.4 | 10,741 | 8.0 |
| Kuala Lumpur | 977 | 3.5 | 1,620 | 38 | – | 8,616 | 5.3 |
| Lima | 4,415 | 4.2 | 930 | 75 | 7.2 | 8,000 | 8.6 |
| Manila | 5,925 | 5.1 | 690 | 45 | 8.0 | 9,187 | 13.3 |
| Mexico City | 15,056 | 5.0 | 2,090 | 105 | – | 7,000 | 3.3 |
| Nairobi | 1,275 | 8.8 | 420 | 47 | – | – | – |
| São Paulo | 12,800 | 4.5 | 2,050 | 151 | 7.8 | 5,469 | 2.7 |
| Tunis | 1,230 | 6.4 | 1,310 | 31 | – | 8,106 | 6.2 |
| Average | | | | | | | 12.9 |
| Industrialized Cities | | | | | | | |
| London | 6,851 | 0.9 | 7,920 | 282 | 2.6 | 8,354 | 1.1 |
| New York | 7,086 | 1.0 | 11,360 | 218 | – | 9,000 | 0.8 |
| Paris | 8,800 | 0.6 | 11,730 | 368 | 12.3 | 4,592 | 0.4 |
| Tokyo | 8,352 | 5.6 | 9,890 | 266 | 2.5 | 3,516 | 0.4 |
| Average | | | | | | | 0.7 |

moved per hour, percentage trips satisfied, and so on, combined with measures of access to activities and facilities, may better reflect the degree to which transport actions are supporting developmental efforts.

In the Third World, variables affecting travel demand are clearly changing, and changing markedly. This is especially true of population and land use factors. Moreover, the economic reality of Third World cities is unstable and prone to unexpected changes.

Finally, it is difficult to accept that urban transport problems will be the same in the contrasting environments to be found in the industrialized and Third World countries. The former are typified by affluence, and the latter by poverty.

Because past transport planning actions have been based largely on the conventional assumptions stated previously, they have not had the desired positive effect on the transport situation of most Third World urbanites. Indeed, it has been argued that these planning actions and their underlying philosophy have themselves become one of the transport problems of Third World cities (*2*). This somewhat ironic situation, coupled with the characteristics of the basic problem, have set in motion a problem-generation chain (Figure 1), which can be described as problem fusion (*4*): the generation of new problems without a significant resolution of the previous one leads to the old and the new fusing together to create a new, more intractable problem.

The main challenge of transport planning in Third World cities in fact rests on finding ways of breaking this problem-generation chain. In addressing that challenge, it is important that sufficient attention be paid to the integration of transport and land use. Perhaps more importantly, there is a need to accept that changes cannot be accommodated in planning without sufficient understanding of the developmental forces underlying them.

The key stages of the conventional urban transport planning process are as follows:

- Explicit formulation of study goals and objectives, and demarcation of the study area;
- Collection of land use, population, economic, and travel characteristics data for the present-day situation, and division of study area into traffic zones;
- Establishment of quantifiable relationships between present-day mobility trends and land use, population, and socioeconomic parameters;
- Prediction of land use, population, and economic parameters for the target date of the study, and the conceptualization of these parameters into a land use plan or plans;
- Prediction of the origins, destinations, and distribution of future mobility demands, based on the relationships established for the present-day situation and the predicted land use, population, and economic parameters;
- Prediction of the human movements likely to be carried by the different modes of travel at the target date;
- Development of alternative highway and public transport networks to serve the predicted land use plan and satisfy the projected pattern and level of movement;

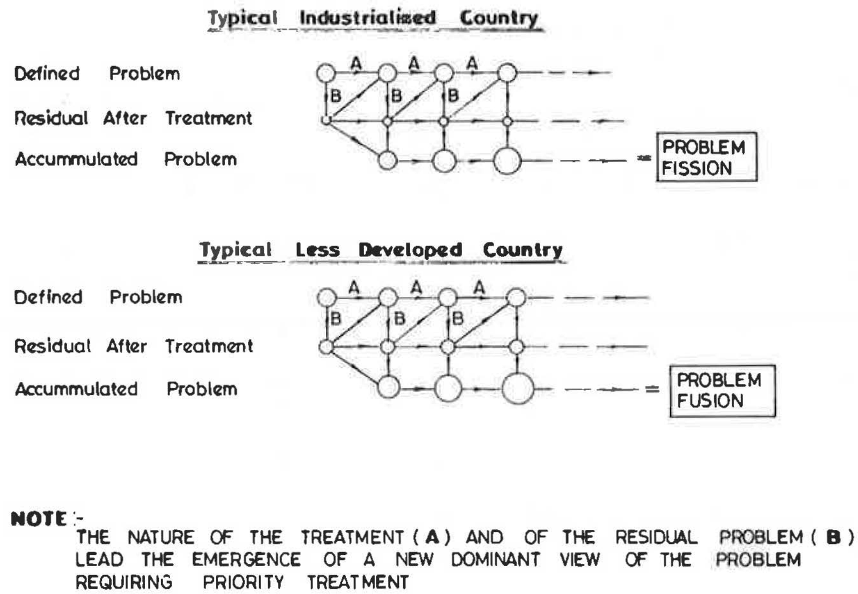


**FIGURE 1 Problem-generation chain.**

- Assignment of predicted trips onto the alternative transport networks or systems to establish how well these devices meet the projected level of travel demand;
- Evaluation of the efficiency and economic viability of the alternative transport networks in terms of economic and social costs and benefits; and
- Selection and implementation of the transport network judged to best serve the declared goals and objectives.

When this process is considered in terms of Third World urban transport problems, it can be seen, for example, that greater attention needs to be paid to the first task, that of definition of study goals and objectives. Second, once defined, the nature and requirements of the dominant goals and objectives should actually influence the tools and approaches used in subsequent study tasks. Models are not a panacea for the transport problem of Third World cities.

### Components of the Third World Urban Transport System

It has been suggested elsewhere (*4*) that the transport system of Third World cities is in fact trihedral in nature:

- A formal, motorized component providing for the needs of the relatively rich;
- An informal motorized component used mainly by the middle- to low-income groups and constituting a source of income and employment for many urbanites; and
- A nonmotorized component used by the rich and poor alike, depending on the mode and the city, that provides income and employment for a significant percentage of the city's poor.

Each of these components has its own characteristics that merit individual attention. Unfortunately, it is the first component that has hitherto attracted the concerted planning attention and implementation funds. Thus this mode is the most "developed" in the sense of having clearly defined structures in the approach to its planning. Indeed, it can be argued that it is only in regard to this component of the Third World city's transport system that the conventional urban transport planning process can claim whatever validity it has in the Third World.

It is only in recent years that the informal motorized sector has attracted planning attention. Previously, such attention was negative: this component was seen largely as a nuisance, a source of traffic congestion and other problems, and was thus to be discouraged. The general view is now more sympathetic. However, there is no generally accepted best methodology or approach to planning for this component, primarily because comparatively little is known about its characteristics and their underlying forces (*5*). This is a rather unfortunate situation because when there are rapidly growing cities and population, it is this component that invariably bears the brunt of the resultant travel demand. Indeed, this component is typified by its dynamism and responsiveness to changing travel demand forces. Thus attempts to understand and influence it require a good appreciation of the relationship between spatial and other developmental forces. This type of comprehension is vital because of the role of this mode as an important source of income and employment for significant numbers of Third world urbanites. Moreover, informal motorized transit is also coming to be an avenue for "indigenizing" automotive technology, with all the attendant positive outgrowths. Even if only this positive developmental effect were considered, the informal motorized transport sector would deserve encouragement.

The third and final facet of the typical Third World city's transport system is the nonmotorized component: travel by animal- or human-drawn vehicles and, of course, by foot. This component, like informal motorized transport, has suffered from the undue emphasis of transport planning actions on the formal motorized component. It also appears to have suffered from attempts to "plan it out" through inadequate provisions in new or overspill settlements and even in redevelopments of central areas.

If the material presented thus far is considered, it is evident that a methodology that will have validity in the Third World will be one that can adequately address the mobility problems associated with each of the three components of the typical

Third World urban transport system, against the background of developmental realities. A possible framework for the integration of transport planning actions has been suggested (*4*). In this framework (Figure 2), an understanding and articulation of overall developmental policies and strategies is seen as a basis for providing coherence and relevance to planning actions with respect to each component of the urban transport system. Because of this method's focus on developmental issues, it seems likely to yield robust and relevant prescriptions. Moreover, it allows identification of unique features of an area or issue, and hence the targeting of specific responses.

### Effective Planning for Third World Urban Transport Needs

Reference was made earlier to the World Bank's assessment of the present transport situation of Third World cities. It should be noted that the large increases in urban population that are taking place largely involve the low-income group, whose members are expected to be increasingly unable to meet the cost of satisfying their mobility needs. Likewise, it is the members of this low-income group who are more often than not located in the emergent peripheral settlements of Third World cities and who are hence making the longer journeys mentioned previously. In contrast, the increases in household income and car ownership have involved and will continue to involve a relatively small proportion of the urban population. Much of the observed road network expansion has been directed toward the satisfaction of the travel needs of this group. If these trends are expected to continue, a need will arise for the adoption of strategies aimed toward (a) increasing the ability of low-income urbanites to pay for their transport needs and (b) reducing the need for motorized transport services and car ownership. Adoption of these strategies will, of course, raise questions about urban development policies and future city structure with respect to existing and new parts of the urban areas.

The question of the urban development and city structure strategies appropriate for Third World cities is of fundamental importance to these governments. It is therefore unfortunate that these strategies are given only passing attention in the current attempts to improve operational efficiency and make better use of existing transport infrastructures. This type of focus, in fact, largely benefits the elite portions of Third World urban populations. In addition, by invariably increasing available road capacity without providing bus priority measures, this focus tends to encourage the use of the automobile more than any other mode.

This concern for improved system efficiency is very much present in the World Bank study mentioned earlier and provides the basis for its recommended strategies: (a) strengthening of transport institutions; (b) transport demand management primarily through road pricing; (c) traffic management, road improvements, and maintenance; (d) road safety measures; (e) public transport improvements; and (f) selected capital-intensive projects. With the possible exception of institutional reforms, all of these measures are transport sector–specific and do not reflect an awareness of the wider context within which solutions must be sought. Indeed, the underlying aim seems to be an increase in available traffic capacity instead of a reduction in the need to travel by making changes in land use allocation. A strategy that fails to recognize the importance of this last factor and the accompanying need to integrate urban transport and land use actions is, in the author's opinion, unlikely to have a significant positive effect on the present transport realities of Third World cities. Moreover, such a strategy fails to recognize that the consequences of the frequently mentioned inefficient operation of Third World cities, especially with respect to movement, are disproportionately borne by the members of low-income groups. Their inadequate means of transportation reduce their ability to improve their developmental state, and the relatively high cost of meeting their mobility needs means that they often have to forgo the satisfaction of other important needs. The inability of low-income groups to achieve their mobility needs cumulatively reinforces their state of economic, social, and political deprivation.

The primary issue that arises in this discussion is the relationship between transport and urban development goals, that is, What is the role of transport in urban development? This is an important question for the Third World, and the perceptions brought to bear on it will determine the type of transport actions prescribed.

The issue that was just raised can be expressed differently: Is transport a catalyst to development or a consequence of development? The thrust of present orthodox thinking, which emphasizes reduced public transport subsidies and the use of financial and efficiency criteria as measures of the effectiveness of transport investment proposals, would seem to support the view that transport is the consequence of development: to require users to bear the cost of the transport services that they consume is to imply that they have attained a certain degree of

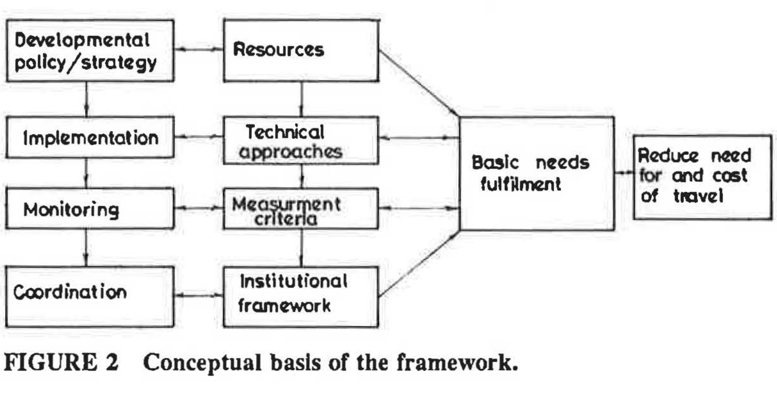


**FIGURE 2 Conceptual basis of the framework.**

economic development. This is a perception that currently places transport planners in apparent conflict with development planners, who believe that the key issue in Third World urban development is the improvement of the economic reality of the urban poor, who make up the major population group. Transport should surely play a catalytic role in this effort and should be provided at costs affordable to the urban poor. This latter viewpoint would appear to be in tune with the World Bank's declared approach to developmental issues of the Third World (*6*):

> Its [the bank's] present development strategies place a greatly increased emphasis on investments that can directly affect the well-being of the masses of poor people of developing countries by making them more productive and by integrating them as active partners in the development process.

Increased accessibility to transport services is arguably one of the best ways of transforming the urban poor into more productive, active partners in the development process. Thus transport must be seen as a means of achieving development.

East, west, or south, the basic problem of urban transport investment is arguably the untraceability of many of its benefits and costs, especially in terms of identifying those bearing the costs and those enjoying the benefits. This problem notwithstanding, the hard evidence is that Western and Eastern nations are willing to subsidize their urban transport systems heavily, suggesting that the tangible and intangible benefits of such investments are accepted as outweighing their perceived and unperceived costs. In the face of this, it follows that the word "subsidy" is perhaps a misnomer when applied to urban transport; rather, it is all a question of what is measured and how.

Moreover, when a subsidy is mentioned in the present approach, it is invariably the result of looking at one side of the balance sheet. The losses made on the transport system are identified, but the profits generated by the increased productivity and efficiency of the city's economy as a result of the provision of transport services are ignored, even when these profits are greater than the perceived losses. The inability to identify and quantify all the benefits should not lead to a denial of their existence.

## CONCLUDING COMMENTS

In this paper, an attempt has been made to highlight aspects of the current realities of transport in Third World cities. From the discussion, it appears that transport planners are presently not equipped to make an impact on the situation. One of the factors identified as contributing to this problem is the historic and continuing concern of transport planners with system efficiency and operational issues at the expense of the wider developmental question of how to help the rapidly increasing number of poor urbanites to improve their economic situation.

The view has been taken in this paper that transport and urban development actions and policies need to be more integrated than they have been hitherto, with transport made subservient to development and used explicitly as a tool for achieving urban development goals. This approach raises many issues, especially about whether the existing body of urban transport planners are equipped to operate within such a framework. This question has been posed and discussed elsewhere (*7*) and deserves the attention of the profession at large, both in industrialized and Third World nations. In that self-examination, a point worth noting is that transport planners are not free of their own values. More importantly, in the Third World they operate in an environment whose political and social milieu is increasingly characterized by a need to respond to the requirements of the urban poor. In this situation, the tools and actions of transport planners must be more responsive to developmental factors than they have been previously.

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# Use of Models by French Consultants for Urban Transport Planning in Developing Countries

RICHARD DARBÉRA

**This paper is based on a survey of 39 urban transport planning studies performed by French consultants in developing countries and on a more detailed analysis of three major cases. Presented are the local conditions that have influenced the choice of the models, the difficulties encountered, the final outcomes of the studies, and the extent to which the plans have actually been implemented. Unless they were constrained by terms of reference set by some international agency, the consultants often took shortcuts through the traditional methodology. They tended to favor straightforward unsophisticated models in which complex equations with many variables are replaced by normative inputs and in which land use forecasts are exogenous or simply taken for granted. In this approach, the role of transport demand modeling is only to ensure that the planned land use would not lead to an unbearable burden on the transport investment budget and, conversely, that planned transport infrastructures were the most suitable for the planned land use. In most cases, simple normative models proved to be quite sufficient and guaranteed good transparence and readability of the mechanisms at work. A more pressing issue is the problem of accuracy in projections of exogenous variables such as population, income, and automobile ownership. French consultants who are confronted with this problem now tend to include modeling packages and training programs with their studies. In this way, they locally install the capabilities to follow up the urban transport situation and to monitor the implementation of the plans.**

French consultants have had a great deal of experience with urban transport planning in developing countries. Before computers were invented, French consultants were drawing transport plans for cities from Brazil (Curitiba, 1930) to India (Calcutta, 1949), and of course for most of the capital cities of the "Empire."

In the late 1960s, at the same time that the U.S. computer modeling techniques for urban transport planning were being introduced to France, French consultants were already using them in Santiago, Chile. Today, 40 capital cities in developing countries have had at least one transport study based on some kind of computer model designed by French consultants.

Is there anything unique about the use of urban transport planning models by French consultants abroad? Are there any lessons to be drawn from this experience?

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## OVERVIEW: FRENCH CONSULTANTS' PRACTICES IN DEVELOPING COUNTRIES

French consultancy for urban transport planning abroad is mainly performed by four large consulting firms: SETEC, SCET, BEEOM, and Sofretu. Three of these companies are public; two of these three specialize in consultancy abroad; and one of these two, which originated as part of RATP (the Paris Transport Authority), specializes in urban transport planning and management.

For the purpose of this paper, a survey of the practices of French consultants in urban transport planning studies for developing countries over the last 15 years was conducted. A questionnaire was sent to the three public consulting firms. The analysis of the answers received allows us to identify some common features of the studies performed by French consultants. Short "expertise"-type missions that did not use some kind of computer traffic demand model have been omitted from the sample. The heavier layout design studies that usually take place when the decision has been made (normally on the grounds of a viability study) to construct a major infrastructure have also been deleted unless they were part of a transport study. In all, 39 cases have been included in the analysis. It is believed that these cases constitute a representative sample of the French consulting experience abroad.

### Scope of the Studies

The scope of the studies ranges from short-term traffic management schemes designed for a limited area of the city to long-term overall transport plans that include large-scale projects like major urban expressways or metro systems. Figure 1 gives the distribution of the sample analyzed here, according to the scope of the study.

Of course, some studies were not easily classified by such a simple typology because they had a different emphasis on one aspect or another. For instance, traffic management schemes often include the provision of bus lanes and bus line reroutings, and road infrastructure planning often addresses the very short term.

### Link with Urban Planning

If the short-term traffic management studies for which the forecasts of future land use are not relevant are excluded, some

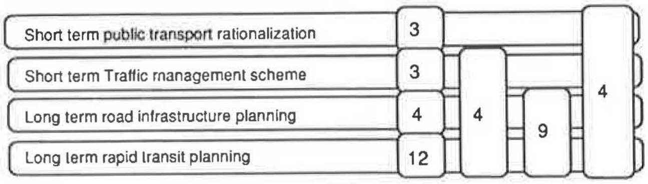


**FIGURE 1 Sample distribution according to the scope of the study.**

kind of Metropolitan Development Scheme already existed or was being completed at the same time by local authorities or by another consultant, in 75 percent of the cases. Different land use and transport hypotheses have been tested in only six cases, but in all but one of the cases (the exception is Santiago), projected urban form was taken as an exogenous variable. The Santiago study is, at the same time, the first study that used computer traffic modeling and the only one that included an integrated land use model. This land use model, which was of the Lowry type, was designed by an engineer who was a member of the consultant team, but it was never used again thereafter. In many cases, when no land use forecasts were available or when they were outdated, the consultants had to determine some kind of future land use pattern themselves to have the necessary inputs to the traffic models.

### Structure of the Traffic Demand Model

In most cases, unless they were constrained by terms of reference set by some international agency, French consultants have been using unsophisticated four-step packages with either gravity or Fratar distribution and normative modal split. The first step of the model, the generation, is generally calculated in an aggregated manner by zone and is based on population, active population, and car-ownership rate. Attraction is based on industrial employment and employment in businesses and services. In 10 percent of the cases, trips by public transport were generated separately. In 75 percent of the cases, the distribution of trips was performed by a traditional gravity model with a distance function calibrated either with household surveys or with some kind of transportation from comparable cases. In nine cases, Fratar-type models were used.

The modal split is certainly the step in which French consultants' practice departs the most from what is done by English-speaking consultants. In only 10 percent of the cases, some kind of logit-type model was used. In some 85 percent of the remaining cases the modal split was performed by using grids. In these grids the traffic zones are grouped according to three to six generation or attraction classes, and the trips between each pair of classes are given a specific normative modal split.

The assignment of automobile trips on the road network is generally performed with standard models that take into account congestion, delays at crossings, left turns, and so on. In some simplified models the network is loaded progressively to allow for a better understanding of the effects of capacity constraints on rerouting. The assignment of public transport trips on bus or rail transit networks can be manual in some simple cases. When the networks were more complex, sophisticated assignment models, originally developed for Lyon or for the Paris region, were used.

Such a general overview does not tell much about the relevance of these practices. This is why specific examples drawn from three major cases (one study in Teheran and two different studies in Casablanca) will be used in the following sections. The local conditions that have influenced the choice of the models, the difficulties encountered, the final outcomes of the studies, and the extent to which the plans have been implemented will all be presented.

These cases have been selected because the studies are old enough that the outcomes in terms of transport policy are known and the projections of land use patterns and the traffic demand forecasts can be compared with what actually happened. In the selected cases, the French consultants, as they often do, have taken shortcuts through the traditional methodology.

The oldest of the cases, the 1972 Teheran Transport Plan study, is quite remarkable because nowhere else in the developing world has a study been immediately followed by a counter-study performed by another consultant. Another interesting case involves Casablanca, where three different consultants (two of them French) at three different times with three different sets of assumptions and three different methods ended up recommending the same erroneous solution, which was the one wanted by the client.

## TEHERAN METRO CONTROVERSY (1972–1974)

In 1972, the Shah of Iran wanted his constricted capital city to be equipped with a modern metro system similar to the systems that the French were constructing in Mexico City; Santiago, Chile; and Montréal, Canada. Sofretu was called in to make an overall transport plan. In Mexico, Sofretu selected the first lines of the metro network without any form of travel demand forecast. This time, Sofretu joined a consortium with other French consultants who specialized in modeling and projections. Because household surveys are by and large the most expensive part of any such study, a method was specially designed to allow using interviews from only 4,700 households.

Sofretu based its land use projections on the 1969 master plan developed for Teheran by Victor Gruen and Associates. The Gruen Plan was devised for a projected 1991 population of 5.5 million people occupying an urbanized area of 715 km$^2$. Because more recent rates of population growth had shown that the Gruen Plan population forecast was a gross underestimate, Sofretu replaced it with a forecast of 8 million people in 1991. Under pressure from local authorities, however, Sofretu assumed that this larger population would be accommodated within the same geographic area assumed by the Gruen Plan.

Sofretu's analysis of current travel in Teheran was based on a home interview survey of 4,700 Teheran households in 1971, on a 151,000 screen line and cordon line interview survey, and on an interview survey of 113,500 bus passengers. Unfortunately, these surveys provided two estimates that differed by nearly 100 percent of the number of person trips made in Teheran in 1971. On the grounds of its experience in other Islamic developing countries, Sofretu concluded that the discrepancy could be explained by the underreporting of trips in the home interview survey and chose the larger estimate of trip making in 1971 as the base line for its traffic forecasts.

To deal with the modal split problem, Sofretu adopted a two-step approach that was quite unconventional by U.S. standards but not uncommon in the studies that French consultants perform in developing countries. The first step takes place in the generation equations, where different sets of equations are derived for people who possess personal means of transportation on the one hand and for people who must take some type of public transport on the other hand. The second step takes place after the distribution of trips, when people who have the choice are distributed between personal modes and rapid transit according to a logit-type model that takes into account the money, comfort, and travel time costs of making trips between different zones. As a result of the study, Sofretu recommended that a metro network be constructed with a length of 60 km by 1981 and 193 km by 1991.

In 1974, a few months after the Sofretu study was completed, the Iranian government decided to ask J. F. Kain, a Harvard professor, to conduct a counter-study. This new study, which used basically the same data but made some provisions for different interpretations, concluded that an expressway system with reserved lanes for express buses would be better suited than the metro system recommended by the French (*1*, *2*). According to Kain, the Sofretu team unintentionally introduced a systematic bias in favor of the metro solution throughout its study.

Kain used a much lower population density and a greater dispersion of jobs than Sofretu did, and he rejected Sofretu's underlying assumption that a metro network would increase population and employment along its lines. He also based his traffic forecast on a different estimate of trip making in 1971, giving more credit to the household survey. Finally, he used a more conventional four-step package that did not differentiate between motorized and nonmotorized trip makers at the generation level.

Construction work on the first metro line started in 1977 as part of a huge land development project to create a new business district north of the old CBD, halfway to a low-density, high-income residential area. A 1-mi-long tunnel had already been constructed when the revolution started. Not much has been done since then, although the project has not been abandoned.

## FIRST CASABLANCA TRANSPORT PLAN (1976)

In 1975, when Transroute (a subsidiary of SCET) was asked to make a transport plan for Casablanca for the years 1982 and 1992, Morocco was experiencing a rapid growth both in per capita income (7 percent per year) and in automobile ownership rate (7 percent per year). Transroute's assignment was to create a short-term traffic management scheme to be implemented immediately and at the same time to forecast transport demand for the years 1982 and 1992 so that a projected beltway could be located and its accesses to the city designed (*3*).

The Transroute team conducted a small household survey (2,800 households) and extensive roadside interviews (58,000 interviews). They also used traffic counts to calibrate the model. Land use forecasts were provided by another French consultant (IAURP, the Paris Regional Planning Agency), which was completing the *Schéma Directeur d'Aménagement et d'Urbanisme*, a master plan for Greater Casablanca.

After Transroute had performed extensive regression analysis (taking into account distance from CBD, income, automobile and cycle ownership rates, family size, type of employment, etc.), they decided to use a simplified generation model where the 57 traffic zones were classified according to six classes of household automobile ownership rates and five classes of employment "attractivity." A specific generation or attraction coefficient by trip destination purpose (i.e., work, school, shopping and others, secondary) corresponded to each class.

The distribution model was of the gravity type. The modal split was normative. It consisted of a grid linking six classes of zones for generating trips with four classes for attracting them. Different grids were set for different trip destination purposes. When the model was compared with the traffic counts, the assignment of the origin-destination matrices reconstituted for 1975 by the model on the existing network proved that this model was fairly accurate despite the simplifying assumptions made.

For the short-term study, these matrices were used to design a traffic management scheme with minor investments and some bus reroutings. The main study addressed the long term. Projections were needed, and different policy options were to be tested.

Projections for 1982 and 1992 were also normative. The average increase in mobility was set at 3 percent per year and then modulated for the different trip destination purposes and for the different automobile ownership rates. The explicit assumption was that both households with a low automobile ownership rate and those with a very high one would have a slower rate of growth than average, according to the classical logit curve.

The modal split projections, as shown in Table 1, were made following two different hypotheses (H1 and H2) that were derived from contrasting policy options. As a result of a policy favoring the private automobile, H1 extrapolated the recently observed evolution of increasing motorization and a correlative diminishing share for public transport. In contrast, H2, which assumed a policy directed toward the provision of better public transport and some automobile usage restrictions, gave an increasing share to public transport trips in the modal split (see Table 1).

TABLE 1 AVERAGE MODAL SPLIT PROJECTIONS IN THE 1976 TRANSROUTE STUDY FOR CASABLANCA (*3*)

| | | 1982 | | 1992 | |
|---|---|---|---|---|---|
| | 1975 | H1 | H2 | H1 | H2 |
| Private automobile | 39 | 50 | 35 | 60 | 30 |
| Public transport | 37 | 30 | 45 | 25 | 55 |
| Cycles | 24 | 20 | 20 | 15 | 15 |
| Total | 100 | 100 | 100 | 100 | 100 |

NOTE: H1 and H2 are the contrasting policy hypotheses described in the text.

Six different road networks, designed specifically to serve the road traffic resulting from the two policies, were tested and evaluated in a cost-benefit analysis based on social and private costs of travel time, vehicle operation, accidents, and investment. Three different patterns of urban growth were also tested, but these patterns were shown to have a much smaller impact on travel demand and total costs than the transport policy variables.

Ten combined bus-LRT (light rail transit) networks were also evaluated by the same procedure. The study arrived at several recommendations. For the short term, aside from the usual one-way street systems and minor redesigning of street crossings, the study recommended that (a) exclusive counterflow busways should be implemented on most heavily traveled corridors, (b) parking charges should be introduced, and (c) several underground crossings should be constructed on one inner street, Boulevard Zerktouni.

For the long term, the study recommended that the H1 policy be rejected and instead presented an implementation schedule for the optimum road network and for one LRT system at ground level. Because there was some pressure from part of the local administration in favor of a metro system, a further simulation was conducted for the year 2002 to check whether a metro would not be more suitable than an LRT in the long run. Citing the results of this simulation, the consultant strongly advised that the metro project be rejected.

Before the study was even completed, work had already started on Boulevard Zerktouni, but the traffic management scheme was implemented 3 years after the consultant had left. After 1 week, the most important part of it—the exclusive bus lanes—was recalled under the pressure of car owners and shopkeepers. A story has circulated that His Majesty the King of Morocco was once caught in a traffic jam caused by the newly implemented traffic scheme and said, "Let it be back to what it was before." According to public opinion, the traffic scheme was just another one of those technocratic decisions made with no regard for common sense. From the foreign consultant's viewpoint, the plan was ineptly applied all at once without any sort of information campaign. Some parking meters had also been installed, but because of a lack of proper maintenance and real enforcement, the meters were out of order very soon and were finally removed and sold to a junkyard. The expressway was constructed 6 years later.

## CASABLANCA METRO REVISITED (1983)

Seven years later, in 1982, Sofretu was asked to make an evaluation and draw up a detailed project for an LRT system along the line indicated by the Transroute study. The Sofretu team had the opportunity of comparing the traffic forecasts and plans established by Transroute with what had actually happened (*4, 5*). They could see that the plans were basically sound and accurate in their intentions. Sofretu noted that the order of priorities should remain exactly the same, but that the plans were several years ahead of their time.

One reason for this overshooting was obvious at the time the Sofretu study started. Because of the war in the Sahara and bad conditions for Moroccan exports on world markets, per capita income had actually declined from 1976 to 1982 instead of continuing to grow at the yearly rate of 7 percent predicted by the Transroute study. As a result, the automobile ownership rate had not increased and had probably declined slightly over the period. The other reason only surfaced after Sofretu was already halfway into its work, when the data from the 1982 census began to appear. Because of underreporting in a poorly managed census in 1960, the demographic projections for Casablanca derived from the 1960 and 1971 censuses were overestimated by 20 percent for 1982 and probably by 40 percent for 1992.

The Sofretu study started with nine screen line surveys of road traffic and a survey of public transport trips along the bus lines adjacent to the projected LRT line. Just as the study started, however, another group of experts was being appointed to draw a completely different master plan for Greater Casablanca. This new plan chose to halt the natural expansion of the city toward unsuitable lands east of the city and favored urbanization along the coast toward Mohamedia, an industrial harbor 10 mi northeast of the city. With this new orientation of city development, the LRT system, with its huge over-capacity toward the southeast, was no longer justified. Nevertheless, the Sofretu consultant continued with what he had been asked to do: (a) forecast the demand for trips by LRT, (b) compute the costs of constructing and operating the system, and of course, (c) conclude that it was viable. When, for aesthetic reasons, the client asked that the project be buried underground for half of its total length, the consultant computed the new investment cost without pointing out that it would not be reasonable to construct such a high-capacity system for only 10,000 passengers on the most heavily traveled segment at peak hour.

The forecasting method was quite simple. A survey of bus patronage was conducted on the bus lines that would be affected by the LRT project, and a very simple Fratar-type model was used to update the Transroute projections and take into account the new population and employment densities scheduled in the last master plan.

## CASABLANCA METRO REVISITED AGAIN (1987)

The Greater Casablanca master plan team firmly opposed the Sofretu project, stating that it would jeopardize the whole master plan by giving an excess capacity in an unwanted direction. Finally, the study's conclusions were rejected when the King of Morocco realized that an underground system would not be feasible given the fact that the underground water level was *only 6 ft deep*. As a consequence, a Japanese consultant was called in to devise a new plan for an elevated monorail that would still be on the very same corridor proposed by Transroute, studied by Sofretu, and rejected by the master plan.

The Japanese team conducted a remarkable study with a thorough household survey and a very elaborate modeling package. They arrived at roughly the same figure that Sofretu did for peak hour travel demand. Just as in the Sofretu case, as the study was going on, the Japanese consultants were progressively asked, for aesthetic reasons, to bury their elevated LRT project into an expensive underground rapid transit system. The Japanese study confirmed the viability of such a system, despite the fact that the projected demand (8,700 passengers at peak hour in 1993) could easily be accommodated by regular buses on exclusive right-of-way.

## CONCLUSION

This general review of French consulting practices abroad has shown that the consultants tend to favor straightforward, unsophisticated models, in which complex equations with many variables are often replaced by normative inputs and in which land use forecasts are exogenous or simply taken for granted. Where does this practice come from? Is it an adaptation to the situation in developing countries?

The simplified approach used by French consultants abroad is very similar to the standardized approach that has been used in most French cities. The urban transport planning technique was imported from the United States to France in the 1960s at the initiative of the French Ministry of Transport by the Ingénieurs des Ponts et Chaussées. It was adapted and standardized, and then the central government required that French cities prepare urban transport plans elaborated according to this method as a prerequisite for obtaining central government transport investment subsidies.

These transport studies, called EPIT (Etude Préliminaire d'Infrastructures de Transport), were to be combined with a master plan, the SDAU (Schéma Directeur d'Aménagement et d'Urbanisme). Because public authorities in France generally have firm control of land use through land development permits that are granted according to the SDAU, there was no pressing need for developing models that were able to forecast the land use patterns that were the "natural" results of transport plans. Rather, local governments were asked to use the models to test two contrasting transport policy options for the long term: one in favor of the development of the automobile as a means of transportation, the other one favoring the use of public transport.

The role of modeling transport demand was thus to ensure that the planned land use would not lead to an unbearable burden on the transport investment budget and, conversely, to ensure that planned transport infrastructures were the most suitable for the planned land use.

One of the objectives of transport studies in developing countries might not be too far from the purposes of the studies in France. In this case, simple normative models have proved to be quite sufficient and guarantee a good transparence and readability of the mechanisms at work.

Another objective of transport studies in developing countries was well illustrated by Gakenheimer in 1982 for the case of Cairo, where the study was used by a special-interest group as a means of having its project be "written on a slate," that is, to exist and be taken into account when transport policies are discussed among decision makers (*6*). For this use, the accuracy of the simulation is not an important feature per se. The reputation of the consultant and the volume of the study are of greater importance: the bigger and the broader in scope, the better. Here, complex models and sophisticated equations are welcome, but they can be balanced by the reputation and references of the transport consulting firm. This is often the case when Sofretu or Deutsch-Eisenbahn Consult is called in.

A more relevant issue is the problem of accuracy in projections. In Teheran the over-optimistic income projection imposed on the Sofretu team, and reluctantly adopted, probably proved to be below that which actually occurred with the rise in petroleum revenues. Inversely, in Casablanca, the reasonable projections made by Transroute completely failed to materialize because of an unpredicted slump in Moroccan export revenues.

After similar experiences in other developing countries, French consultants now tend to include modeling packages and training programs with their studies. These materials allow local transport engineers to follow up the urban transport situation and monitor the implementation of the plans. Sofretu followed this procedure in Algiers, and recently proposed it for Morocco.

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# Stepwise Regression Model of Development at Nonmetropolitan Interchanges

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**After a brief outburst of research on the Interstate highway system soon after its construction, the network and its varied and wide-ranging aptitude for reshaping the nonurban United States were bypassed as major points of contention by social scientists. Land use conversion brought about by the system is a logical measure of the network's microlevel impact on rural and nonmetropolitan areas and is the focal point of this paper. This study features a stepwise regression model that explains over 50 percent of the variation in interchange area development at 65 nonmetropolitan Kentucky interchanges. The procedure relies on four independent variables (preconstruction development, interchange type, whether the site permits the legal sale of alcoholic beverages, and whether the interchange is in Appalachia) to predict the dependent variable, which is current development. The results of this study indicate the widely diverse development process found around nonmetropolitan Interstate interchanges. Both the theoretical and applied aspects of transportation-related development are considered by this model.**

After a brief outburst of research on the Interstate highway system soon after its construction, the network and its varied and wide-ranging aptitude for reshaping the nonurban United States were bypassed as major points of contention by social scientists. Land use conversion brought about by the system is a logical measure of the system's microlevel impact on rural and nonmetropolitan areas, but this factor is minimized in the literature. This undertreatment is true for nometropolitan areas in general. The current study seeks to complement the growing literature on urban land use and conversion with an examination of intensified change in nonurban land use. In addition, the paper presents a model of variable development in interchange areas.

Historically, the Interstate highway system has been an important element in the transportation engineering literature (*1*). Most efforts have concentrated on the design and traffic aspects of the network, but some have addressed the land use issue (*2–4*). Most studies have focused primarily on urban areas. As concentrations and centers of impact, nonmetropolitan interchanges captured some of the early attention of researchers who were interested in the Interstate network. More recently, however, these interchanges have drawn a minimum amount of attention relative to their innate ability to reshape landscapes on a large scale. Because of this limited amount of investigation, interchanges and their highly variable potential for changing land use are misunderstood throughout the academic, planning, and professional communities. The impact has been viewed as a function of traffic volume and distance from urban places by those attempting to understand the process of transportation-related development. None of the investigations into the variation of changes in interchange-specific land use have resulted in a satisfactory model (*5, 6*). This study established the complexity of the land use modification process that occurs at nonmetropolitan interchanges by using site and situational characteristics to both explain and forecast interchange development.

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## METHODOLOGY

Interchange construction and development are indicators of and significant factors in the land use conversion process and are the focus of this paper. To understand interchange development it is necessary to (a) define and measure the developmental complexity of a set of nonmetropolitan interchanges; (b) identify variables that contribute to, retard, or alter the measured complexity; and (c) test the worth of the independent factors in explaining variable interchange development by building a land use conversion model.

Kentucky is an ideal site for an analysis of nonmetropolitan interchanges. Since local Interstate highway construction began in Jefferson County in 1956, total state mileage has since grown to 738. In Kentucky the Interstate system constitutes 1.1 percent of the state's total highway mileage while it carries 23 percent of the traffic (a figure almost identical to that of the national system). Five highways, 40 counties, and all of Kentucky's major cities are incorporated into the national network. Although the system's function is to connect major metropolitan regions, its routes pass through rural areas lying between these nodal cities, providing the potential for direct, high-speed access to or through places that might previously have been remote and relatively inaccessible.

Because the focus of this study is nonmetropolitan counties with Interstate highway interchanges, only the counties that are categorized as nonmetropolitan by the U.S. Bureau of the Census and contain one or more interchanges are included. Every Interstate highway in Kentucky crosses through nonmetropolitan counties, providing a set of 65 interchanges for analysis (Figure 1). Interchanges are defined as points at which traffic can enter or exit the Interstate highway from or to another road. Because of the regional, temporal, directional, and design differences among Kentucky's Interstate highways, a study based on the state's nonmetropolitan interchanges facilitates a comparison with nonmetropolitan interchanges in other states, especially those east of the Mississippi River.

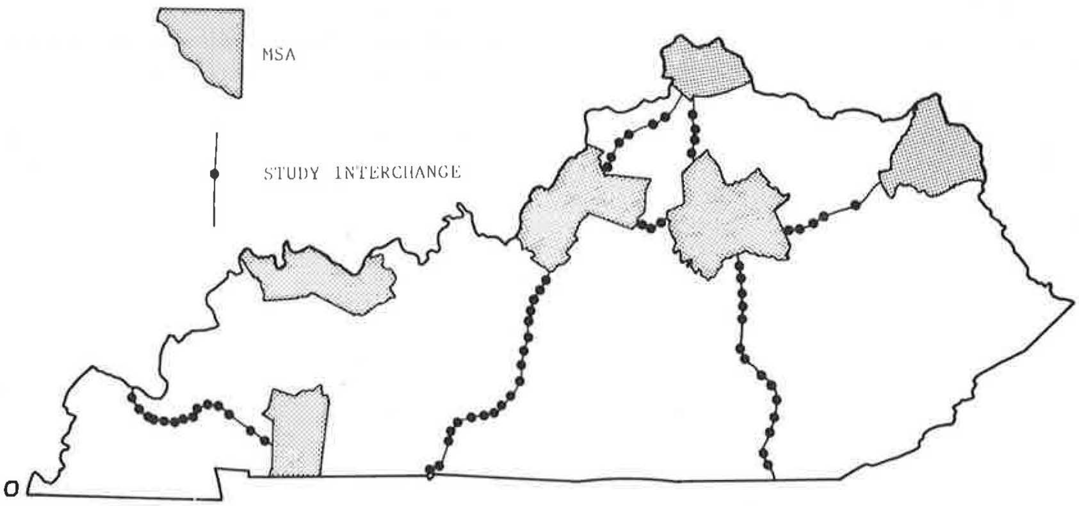


**FIGURE 1 The Interstate highway system through Kentucky.**

A 502-acre area around each of the 65 interchanges in Kentucky was studied (7). This size was selected for the study area because of its proven significance in an earlier analysis and its successful prestudy testing in Kentucky. R. D. Twark discovered that most new economic development at Interstate highway interchanges occurs within 0.5 mi of the intersection. For that reason, he defined the area within that distance of the crossroads as the "interchange community" and emphasized its usefulness as a study region. This particular acreage, then, is calculated from a 1-mi-diameter circle centered on the interchange. The reason for the choice of a circular study area is that linear strip analysis tends to deemphasize development on roads parallel to the Interstate highway. Furthermore, square or rectangular study areas overemphasize the corners, which are removed from the immediate influence of the interchange.

This analysis utilizes a simple, straightforward definition of development that is consistent with that found in the related literature. In this case, development is a cumulative term, indicating the presence of actual structures at an interchange site that possess both a structural and an activity component. Developmental complexity incorporates the size and scope of entities located at interchange sites and a measure of the activity that the particular facilities generate. Because structures may include a wide variety of patterns, sizes, and uses, a simple count of the individual buildings in each study area is inappropriate and misleading (i.e., a tobacco barn is not equal to a convenience store in size or in activity generated). Therefore buildings are divided into size categories on the basis of their size and ability to generate traffic: simple, nonresidential; single-family residential; multifamily residential; small commercial and small institutional; large commercial, large institutional, and small industrial; and large industrial (more than 20,000 ft$^2$). Building numbers recorded by category in the field at each interchange are weighted on the basis of the buildings' size and ability to generate traffic. On the basis of extensive field checking and trial-and-error–type runs, the weightings selected for the six building categories are

1: Category I (simple, nonresidential);
2: Category II (single-family residential);
4: Category III (multifamily residential);
8: Category IV (small commercial and small institutional);
16: Category V (large commercial, large institutional, and small industrial); and
32: Category VI (large industrial).

The developmental complexity of each study area is calculated by summing the number of building present in each category and multiplying by the appropriate category weight, then totaling the category sums. For example, if a particular study area contains 20 single-family homes, 5 barns, and 4 service stations, its developmental complexity score is

$$[(20 \times 2) + (5 \times 1) + (4 \times 8)] = 77$$

This number, representing the level of land use conversion or construction at each interchange, is the dependent variable recorded at the 65 observation sites in this study.

The impact of Interstate highway interchange construction can be expected to vary from place to place, depending on a variety of local and site-specific characteristics. According to the literature, traffic volume, interchange type and age, topography, and distances to urban areas are factors that influence developmental complexity. Yet these factors have proven incapable of explaining variation in interchange development. A conclusive approach apparently involves the examination of a broader and more comprehensive set of variables. Variables that measure the historical, spatial, economic, population, and social attributes of a place must be included.

Independent variables of land use, engineering, traffic, social, regional, population, and geographic natures were introduced into the analysis. For each study interchange the following data were collected. Variable 1 serves as the dependent variable, whereas variables 2–31 serve as independent variables in this analysis:

1. Current developmental complexity,
2. Average daily traffic count,
3. Interchange age,
4. On a north-south highway,
5. In the Bluegrass Region,
6. In the Pennyroyal Region,

7. In the Jackson Purchase Region,
8. On a state highway,
9. On a federal highway,
10. Number of preconstruction land owners,
11. Cloverleaf type,
12. Diamond type,
13. Half type,
14. Leg type,
15. Double type,
16. Diamond/cloverleaf type,
17. Distance to the nearest neighboring interchange,
18. Distance to the farthest neighboring interchange,
19. Exits to a major tourist attraction,
20. Distance to the nearest city,
21. Distance to the nearest Metropolitan Statistical Area (MSA),
22. Distance to the nearest city with a population greater than 25,000,
23. Number of workers commuting into the county,
24. Number of workers commuting out of the county,
25. County population,
26. Percentage of the county's population that is urban,
27. Preconstruction developmental complexity,
28. Dominant soil capability classification at the interchange,
29. Areal size of the developable portion of the interchange study area,
30. Whether the area restricts the legal sale of alcoholic beverages, and
31. Whether the interchange operates within Appalachia (a measure of latent demand).

Variables 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, and 19 are entered as dummy variables. For example, if an interchange connects an Interstate highway and a county road, the values introduced at that particular observation for variables number 8 and 9 would be 0. The effect of that characteristic would be felt in the constant or *Y*-intercept, an especially critical figure in this type of analysis because it holds the combined effect of all null dummy variable measures. Had the intersecting road in question been a federal highway, variable number 9 for that observation would have a value of 1.

The SPSS-X stepwise regression procedure combines forward and backward entry to construct a model. The routine introduces an initial variable into the regression equation according to its explanatory power, then searches for a variable that will complement the previously selected variable and increase the multivariate correlation coefficient. Throughout the model-building process, this technique searches the matrix of correlation coefficients to find the minimum number of variables that provides the maximum amount of explained variation. A significant advantage that this more advanced stepwise procedure holds over prior techniques is its ability to emulate a backward entry procedure by removing once-entered variables from the equation to achieve the optimal equation. This ideal end product is a combination of variables that fit together in a way that maximizes explanatory power and minimizes collinearity within the model. By addressing the collinearity problem, this method greatly reduces the tendency that many regression techniques have toward explaining only a small portion of the total variation in the dependent variable. This technique selects variables for entry into the equation on the basis of their ability to explain a different portion of overall variation. As the primary ingredient in this methodology, stepwise regression allows a common and easily reproducible modus operandi for scholars and planners alike.

## MEASURED COMPLEXITY

Among the 65 study interchanges, developmental complexity scores range from 13 at one Marshall County interchange to 1,616 at an interchange in McCracken County. The mean score among all study interchanges is 323.815. The typical interchange study area of 502 acres contains over 102 structures, including all types of both residential and nonresidential buildings. Most dominant among building types are single-family residences, whereas industrial facilities are most infrequent. As percentages of total interchange complexity, the following category values indicate the level of influence that each structure type carries in the overall analysis:

- 40.94 percent: Category IV (small commercial and small institutional);
- 29.29 percent: Category II (single-family residential);
- 14.82 percent: Category V (large commercial, large institutional, and small industrial);
- 10.08 percent: Category I (simple, nonresidential);
- 3.50 percent: Category III (multifamily residential); and
- 1.37 percent: Category VI (large industrial).

The relationships between the dependent variable and the set of independent variables as pictured in the matrix of correlation coefficients reveal a complex picture of the factors that influence interchange development (Table 1). For example, the strongest relationship between developmental complexity and an independent variable involves preconstruction complexity ($r$ = 0.563). Other variables that exhibit relatively strong positive relationships with developmental complexity are number of preconstruction land owners ($r$ = 0.368) and number of out commuters ($r$ = 0.362). Among the more significant detriments to development that can be identified from the matrix are location in the Pennyroyal region, increased distance to cities of any size, and a more limited topography. An interchange's relative proximity to a city of any size provides the strongest negative relationship in the data set, −0.358, because complexity decreases as distance increases. Interchange areas near cities are generally more developmentally complex than those further removed from the influence of urban places. These figures alone only hint at the overall development process, for they merely suggest simplified measures of influence while holding other factors constant. From the correlation coefficients, no single independent variable can be identified as a satisfactorily strong factor in development, and collinearity is highly visible in certain areas of the matrix. These two characteristics of the matrix are resolved by the stepwise regression technique while it searches for multivariate influence and reduces collinearity.

TABLE 1 CORRELATIONS BETWEEN INDEPENDENT VARIABLES AND THE DEPENDENT VARIABLE ($Y$)

| Independent Variable | Correlation With $Y$ |
|---|---|
| 2. Average daily traffic count | 0.32 |
| 3. Interchange age | 0.07 |
| 4. On a north-south highway | −0.01 |
| 5. In the Bluegrass Region | 0.01 |
| 6. In the Pennyroyal Region | −0.26 |
| 7. In the Jackson Purchase Region | 0.23 |
| 8. On a state highway | 0.03 |
| 9. On a federal highway | 0.08 |
| 10. Number of preconstruction land owners | 0.37 |
| 11. Cloverleaf type | −0.12 |
| 12. Diamond type | 0.10 |
| 13. Half type | −0.07 |
| 14. Leg type | −0.14 |
| 15. Double type | 0.30 |
| 16. Diamond/cloverleaf type | 0.06 |
| 17. Distance to the nearest neighboring interchange | 0.00 |
| 18. Distance to the farthest neighboring interchange | −0.06 |
| 19. Exits to a major tourist attraction | −0.11 |
| 20. Distance to the nearest city | −0.36 |
| 21. Distance to the nearest MSA | 0.15 |
| 22. Distance to the nearest city > 25,000 | −0.07 |
| 23. Number of workers commuting into the county | 0.27 |
| 24. Number of workers commuting out of the county | 0.36 |
| 25. County population | 0.32 |
| 26. Percent of the county's population that is urban | 0.35 |
| 27. Preconstruction developmental complexity | 0.56 |
| 28. Dominant soil capability classification | −0.29 |
| 29. Size of the developable part of the study area | −0.02 |
| 30. Whether the area restricts the legal sale of alcoholic beverages | 0.33 |
| 31. Whether the interchange is in Appalachia (a measure of latent demand) | 0.20 |

## THE MODEL

The form of the stepwise regression model utilized here is as follows:

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4$$

where

$Y$ = expected developmental complexity;
$a$ = constant or $Y$-intercept (particularly important in this analysis because it contains the joint effect of all null dummy variable measures);
$b_{1...4}$ = regression coefficients accompanying each variable; and
$X_{1...4}$ = measured value of each $X$ at the proposed interchange site.

Because preconstruction developmental complexity has a stronger relationship with the dependent variable (current developmental complexity), it is selected by the procedure for initial entry into the regression equation. Preconstruction developmental complexity is measured in the same way as the current complexity. This historical measure identifies the level of development in a study area prior to highway placement and is drawn from preconstruction aerial photographs. The mean preconstruction developmental complexity score for the 65 nonmetropolitan sites is 49.94. Unlike current developmental complexity, preconstruction complexity is most influenced by single-family residences and not commercial or institutional establishments. Of the total complexity measure at an average interchange, 57.55 percent can be attributed to single-family housing, as compared to less than 30 percent of current scores. A typical interchange study area contained 28.13 structures prior to construction of the Interstate highway through the area. In general, the 502-acre site was the location of 14.37 single-family residences; 12.77 simple, nonresidential structures; 0.71 small commercial or small institutional facilities; 0.14 multi-family residential buildings; 0.14 large commercial, large institutional, or small industrial operations; and no large industrial enterprises. Preconstruction developmental complexity alone explains 31.66 percent of the variation in current complexity.

Second, the procedure enters the double interchange variable as the next independent explanatory factor. The technique omits the ownership variable in spite of the fact that its $r$ score is greater than that of the chosen variable. Its omission is based on the strength of its relationship (0.684) with the previously selected variable (preconstruction developmental complexity). This is an excellent example of the procedure's ability to minimize collinearity in the equation. Seven geometrically distinct interchange types are currently open to Interstate traffic in nonmetropolitan Kentucky. Of the 65 study interchanges, 55 are diamond-shaped, five are trumpet-shaped, three are leg or M-shaped, two are halves of double interchanges, two are diamond/cloverleaf combined, one is a cloverleaf, and one is a half-diamond. Interchanges that serve as halves or ends of a double interchange encourage large-scale development, whereas trumpet interchanges discourage land use change. Double interchanges generate and are surrounded by 170 percent more development than the mean figure. Variable levels of access and visibility to goods and services at double and trumpet interchanges result in these higher levels of investment. With the addition of this second variable, the model's explanatory power is increased to 39.32 percent.

Third, the procedure enters the "wet" variable (i.e., variable 30, which indicates restriction on alcohol sales) into the equation to produce an explanatory capability of 46.10 percent. Social preferences of surrounding populations retard or spur interchange development. Of the 65 study interchanges, only 19 are legally categorized as "wet" (i.e., allowing sale of alcohol) while the remaining 46 forbid the sale of alcoholic beverages, including beer and wine. Wet interchange areas are 50 percent more developed than their dry counterparts.

Finally, a fourth independent variable, an interchange's presence in Appalachia, is entered into the equation. Of the 65 study interchanges, 19 lie in the part of Kentucky so identified, whereas 46 fall outside the region. Of the 19, 5 are located along Interstate 64, east of Lexington, and the remaining 12 lie south of the same city on Interstate 75. One of these southern interchanges connects with the Appalachian Development Highway System at London, Kentucky, providing impetus for interaction between and within Appalachia. Appalachian interchange areas are almost 20 percent more developed than their non-Appalachian counterparts.

Given the results of the stepwise procedure above, the following values would be introduced into the equation:

$a$ = −33.098874,

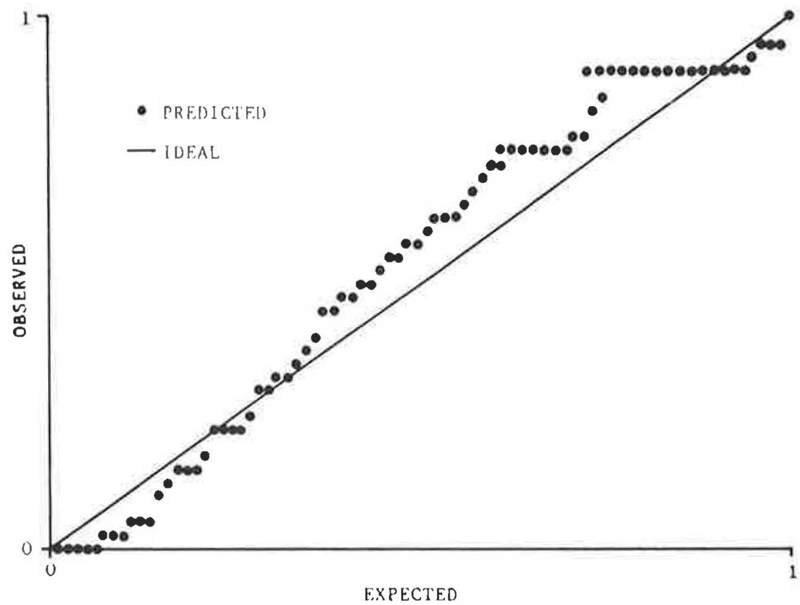


**FIGURE 2 Plot of standardization residuals (65 observations).**

$b_1$ = 5.387014,
$b_2$ = −1,025.030050,
$b_3$ = 214.671303, and
$b_4$ = 193.920165.

The model has an overall explanatory capability of 53.07 percent (Figure 2). Both logarithmic and square root data transformations failed to significantly improve explanatory power.

## SUMMARY AND CONCLUSION

The land use conversion process documented in this study is a complex one. Whereas prior studies attempted to explain and forecast interchange development with a limited number of independent variables, the model presented here utilizes 4 variables drawn from a list of 30 independent variables. These results should encourage planners to recognize the role of nonsystem factors in development and include them in the transportation planning process. Land use conversion is a complicated process, driven by a variety of variables at work in different spatial circumstances.

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# Transport in Rural Areas of Developing Countries: Empirical Findings from Western Province, Zambia

BEN H. IMMERS, ERNST J. MALIPAARD, AND MICHEL J. H. OLDENHOF

**The focus of this paper is the transport problems of people living in rural areas of developing countries. Because the majority of these people are engaged in small-scale farming, special attention is given to the relationship between agricultural activities and transport. It is indicated that although the quality of the road infrastructure in the Western Province of Zambia is very poor, attention should be paid first of all to both the small variety and low availability of intermediate transport means. In addition, it is noted that agricultural transport is heavily influenced by the organizational structure of farming households and by governmental involvement.**

The quality of the transport system is an important indicator of the level of socioeconomic development of a specific country. Harbors, railways, and roads are necessary for import, export, and distribution of goods and movement of people. More or less in accordance with size and nature of transport demand, the coarse network of railways and motorways (trunk roads) branches into a dense network of arterials, feeder roads, rural access roads, tracks, trails, and footpaths. As a result of the amount of goods to be transported, the topography, and the local level of technical advancement (motorization), among other factors, most countries have a variety of vehicles to transport people and goods.

This general picture also applies to African (sub-Saharan) countries. With respect to these countries, however, some further comments must be made:

- The local level of technical advancement is low, even in comparison with developing countries in Asia and South America;
- The majority of the population lives in rural areas and consists of subsistence farmers; and
- The transport system in rural areas is poorly developed.

This transport system, consisting of both roads and vehicles, often acts as a major bottleneck in realizing any socioeconomic development. Many donor aid programs are therefore geared toward improvement of the transport system. These projects often have the following characteristics in common:

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- The chosen solutions and applied techniques require skills that deviate greatly from the local level of expertise. This inevitably leads to exclusion of the local population in realizing the project. Consequently, the local population does not feel any responsibility for continuing (maintaining) the project.
- Many solutions are heavily biased toward motorized traffic, even though most of the local trips (both rural and urban) are made on foot or by bicycle.
- A sectoral approach is used that does not take into account interrelations with other sectors, for example, agriculture. This approach does not recognize that transport is actually a derived need.
- The technical approach chosen leaves out the social and cultural factors that will be predominant in determining the acceptance of chosen solutions.

This kind of development strategy has resulted in many large-scale, high-tech development projects that benefit only a small part of the population, that is, those living in urban areas. The greater part of the population is still facing the same (or even worsened) problems. The transport demands of this group are directly related to basic needs fulfillment: fetching water, collecting firewood, and farm-to-field transport and marketing of agricultural surpluses. Almost all of the trips necessary to perform these activities are made on a network of tracks, trails, and footpaths, far away from the paved road (*1*, *2*). The means of available transport are very simple: at best, an oxcart, wheelbarrow, or bicycle, and in most cases, head-, shoulder-, or back-loading. This transport situation has several consequences (*3*):

- Transport is time consuming and, consequently, particular services (rural health center, school, etc.) are out of reach; and
- The transport of goods on head or shoulder (often several times per day) is arduous; in combination with other factors (e.g., poor marketing facilities) this factor may restrain farmers from producing surpluses.

The rural transport situation in relation to agricultural activities and accessibility of services and the possibilities for improvement by use of low-cost transport facilities are the main topics of this paper. The findings presented are the result of a research project carried out in 1986 in Western Province, Zambia. In consultation with the local transport authority, the Western Province Planning Unit, three project areas were selected to get a general overview of the actual situation in Western Province.

First, an overview of the local economy of Western Province is given. This overview and the description of the local transport system are based on interviews with farmers as well as with key informants. Some of the conclusions and recommendations, which are based on the fieldwork, are generalized with respect to developing countries (with particular reference to sub-Saharan Africa). More detailed information on this study can be found in the work by Kolsteeg et al. (*4*).

## LOCAL ECONOMY OF WESTERN PROVINCE

The vastness of the province, in combination with an extremely low population density (4.2 people/km$^2$), has had a severe impact on the development of the Western Province (Figure 1). The agricultural potential of the sandy uplands is generally poor because of the low fertility of the soils. More than 75 percent of the population is directly engaged in subsistence agriculture, and 87 percent live in the rural areas. Employment in the formal sector is very low, and employment in the informal sector does not seem to be significant (*5*).

In line with the national policy, maize (American corn, *Zea mays*) has been promoted as a dominant staple crop through favorable pricing, marketing, and credit facilities, whereas hardly any marketing outlets were provided for traditional staples. Although traditional staples require less input for surplus production and are less sensitive to timely input and distribution, their cultivation involves disadvantages as well. Urban consumers have long been used to maize consumption (a colonial inheritance) and therefore prefer maize as their staple food over cassava, sorghum, or millets. Also, cassava requires extensive processing before milling.

As in many other African countries, the lack of sufficient human resources is a severe constraint on agricultural development. In Western Province, this constraint has been slightly loosened by a wider use of cattle for tillage and transport purposes. In contrast to farm machinery (tractors), the use of animal draught power (ADP) has several advantages. The number of cattle in Western Province is favorable and should be sufficient to extend the role of cattle in cash cropping. In addition, ADP is less dependent on external factors, for example the devaluation of the Kwacha (currency of Zambia), which drives up the import price of machine fuel.

However, an extended role for cattle is severely hampered by several other factors. The geographical distribution of cattle within the province is highly uneven, mainly due to traditional factors. Generally speaking, oxen are underutilized, also mainly for traditional reasons. The role of cattle in the traditional economy is not restricted to transport and tillage; as an

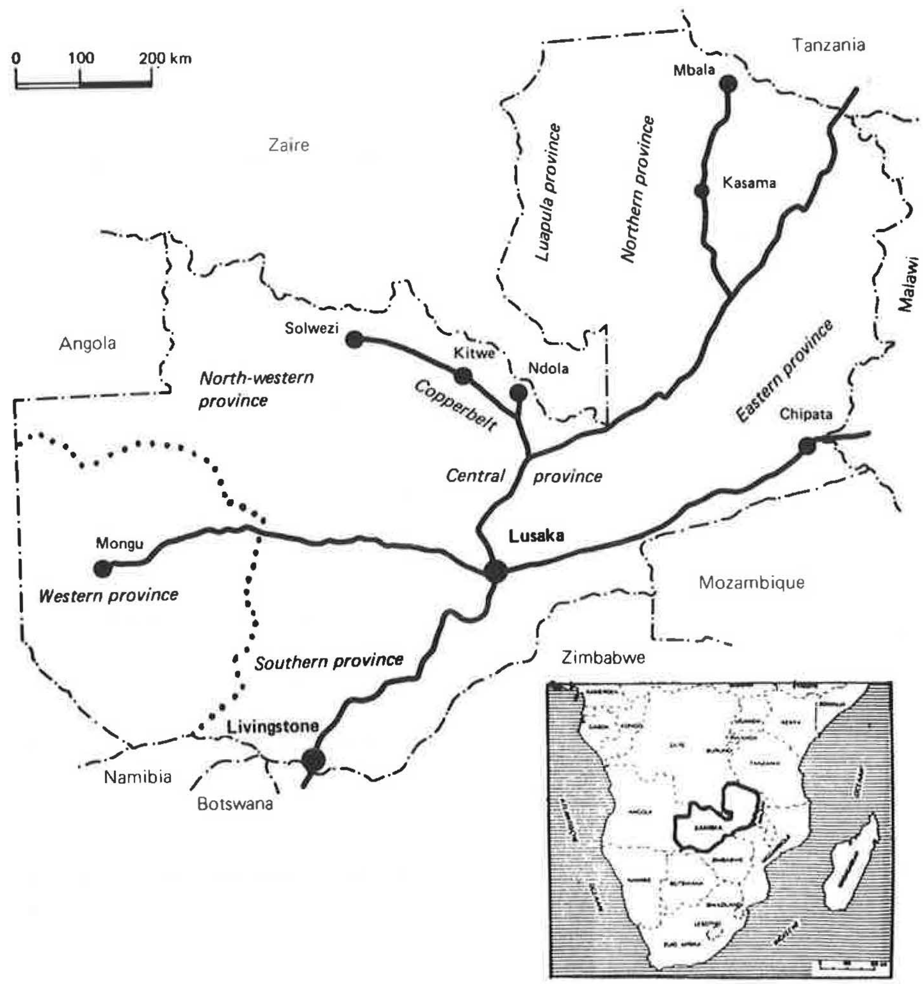


**FIGURE 1 Zambia.**

example, exchange of cattle is also used to build social relationships. Therefore, efficient commercialization of cattle is not that simple. Another factor is that hardly any medium-term credit facility is available for the procurement of a span of oxen in combination with a plough or oxcart. Additionally, an increasing number of parts of the province are infested with tsetse flies, which carry a cattle and horse disease called nagana as well as the notorious human "sleeping sickness." Finally, the quality of farming implements is poor. Oxcarts are expensive and rarely available. In addition, facilities for farming implement repair are scarce.

For most rural inhabitants, farming (cultivation of staple crops) is the primary source of income. It is hard to quantify the extent to which this income is replenished by additional sources of income. An estimate of an average farming household's income is shown in Table 1. It has been assumed that maize is the only cash crop. As an illustration of the purchasing power of the calculated income in Table 1, these 1986 prices of essential consumer goods should be considered:

Sugar (2 kg): K 4 (K = Kwacha);
Cooking oil (750 ml): K 7;
Blanket: K 45;
Pair of trousers: K 40–80;
Bicycle: K 545;
Public transport (100 km): K 5.

The inability to invest in farming equipment is clearly illustrated by these 1986 prices:

Oxcart: K 2,500;
Plough: K 250;
Wheelbarrow: K 250;
Span of oxen: K 1,200–1,500.

TABLE 1 GROSS CASH FARM INCOME, SMALL-SCALE FARMER (1985–1986)

| | Cost/ Revenue (K) |
|---|---|
| Seasonal expenditures | |
| Ploughing | 160 |
| Fertilizer | 301.1 |
| Seeds | 47.1 |
| Transport, maize bags | 51 |
| Transport, fertilizer and seeds | 10.8 |
| Handling charges | 8.5 |
| Labor costs | 70.4 |
| Total expenditures | 648.9 |
| Revenues from maize | 1,196.8 |
| Average gross cash farm income | 547.9 |

NOTE: The following assumptions were made: average hectarage of maize cultivated, 1.28; application of fertilizer, 245 kg/ha; no seasonal load obtained; land ploughed by (hired) oxen; labor costs (weeding), K 55/ha; and marketed maize production: 1957.5 kg/ha. The share of transport costs is 10.6 percent of the total costs.

Obviously, despite some nonagricultural extra earnings, the general outlook for the financial situation of most farmers is gloomy and can even be expected to deteriorate. Because of the fluctuating exchange rate of the Zambian Kwacha, the farm income is hard to translate into U.S. dollars. For comparison, in July 1986, \$1 = K 5; but in October 1986, \$1 = K 13. It is important to note that the calculation of "gross cash farm income" uses the marketed surpluses instead of the actual production. The difference between actual production and marketed surpluses is the portion of the production that is retained for home consumption. Therefore the retained quantity should be added to the calculated "gross cash farm income" to arrive at the "gross farm income." The problem with maize, however, is that the subsistence part can be valued at the official producer price, at the cost price plus normal profit margin, or at consumer price.

## LOCAL-LEVEL TRANSPORT SYSTEM

Trip making is necessary because of the variety of activity locations. Thus the local-level transport system and the activity pattern of the household are interrelated. To gain insight into the local level transport system, it is useful to distinguish the demand for trips and the supply side of the transport system. Through a comparison of supply and demand the inadequacies of the transport system will become visible.

### Supply Side of the Transport System

The supply side of the transport system is mainly determined by vehicle ownership, supply of road infrastructure, and operations management. In general, transport conditions within Western Province are poor. Most of the province is covered by a deep mantle of Kalahari Desert sands. Consequently, the quality of feeder roads is low, mainly as a result of loose sand. Only in hard-sand areas (the northeastern parts of the province) are the feeder roads negotiable by conventional motorized vehicles (two-wheel drive). Ownership of motorized vehicles is negligible and is mainly restricted to the government and donor aid institutions.

The density of paved and all-weather gravel roads is low. There are not sufficient funds for maintenance of the present trunk and feeder roads, mainly due to the scarcity of road-building material and the long haulage distances.

Nearly all public transport services in Western Province are offered by the United Bus Company of Zambia. The areas served are restricted to those accessible by paved or gravel road. Both the frequency and reliability of these routes have tended to decrease. The shortage of foreign exchange has direct repercussions on the operational fleet (acquisition of spare parts, fuel, etc.). Finally, the majority of people cannot afford frequent use of public transport.

The most common means of transport used by farmers is the ox-drawn sledge (Figure 2). A sledge consists of a solid wooden frame, V-shaped, with a load carrier of sticks and shelves mounted on the runners. High tractive power is required, especially in loose-sand areas. However, sledges cost little, require no spare parts, and are mostly manufactured by the owner. Sledge ownership is mainly constrained by the availability of trained oxen. The average carrying capacity is about 200 kg (a sledge weighs 70 kg), depending on the number of oxen (one, two, or three pairs) and the condition of the track. The average speed of a sledge is only 3 km/hr when

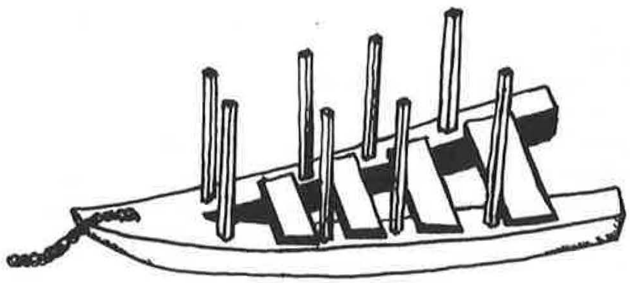

FIGURE 2 Ox-drawn sledge.

loaded. The oxen need 1 hour for grazing and resting after every 2 hours of hauling.

Oxcarts are less common. The low level of ownership is caused by the current low manufacturing capacity within Western Province and by an inadequate supply of spare parts and tire repair facilities. In addition, the majority of farmers cannot afford this mode of transport (2). In general, the inhabitants have a very positive attitude toward the use of oxcarts. The use of pneumatic tires is justified because the large contact area of tire and road surface allows transport even in loose-sand areas (6). Those few people who are familiar with wooden wheels regard them as inferior.

Private ownership of tractors for both land cultivation and transport is negligible. Tractor ownership in Western Province has decreased as a result of the high foreign exchange component in operating costs and the economic recession.

Bicycles are common in rural areas of Western Province, although usage is mainly restricted to hard-sand areas. The quality of bicycles is poor. Although people are eager to maintain their bicycles properly, a considerable number have broken down because of a lack of spare parts (mainly inner tubes and tires, patches and adhesive) and tools. Because of their poor quality, bicycles are seldom used for agricultural transport. There is only one bicycle factory in Zambia. Recent price increases are discouraging wider ownership.

Wheelbarrows have proved to be a very useful means of transport, both for on-farm transport (using narrow footpaths) and for short marketing trips. However, all wheelbarrows are made of steel and thus expensive. Donkeys are not common in Western Province, although they could be very useful for personal and goods transport, especially in loose-sand areas. Pack panniers or carts would be used to allow efficient transport by donkey. The low level of ownership can be partially explained by the fact that donkeys, in contrast to oxen, do not give their owners any status. In surrounding countries (e.g., Botswana, Zimbabwe), donkeys are used extensively.

### Demand Side of the Transport System

The demand for transport can be subdivided into on- and off-farm transport (Figure 3). On-farm transport is characterized by trips for agricultural and domestic activities, whereas off-farm transport can be defined as the movement of goods from farm to market, Primary Cooperative Society, or road and back again. Trip making for social contacts and services is included in off-farm transport.

General features of the on-farm transport are

- Movement of small loads (10–100 kg),
- Relatively short distances (1–5 km),
- High frequency, and
- Potential involvement of all members of the household (women perform the majority of transportation tasks by head-loading).

The off-farm transport can be described by

- Movement of heavier loads (up to 500 kg),
- Relatively long distances,
- Low frequency, and
- More involvement of men, combined with the use of an intermediate transport means (all modes above human portage

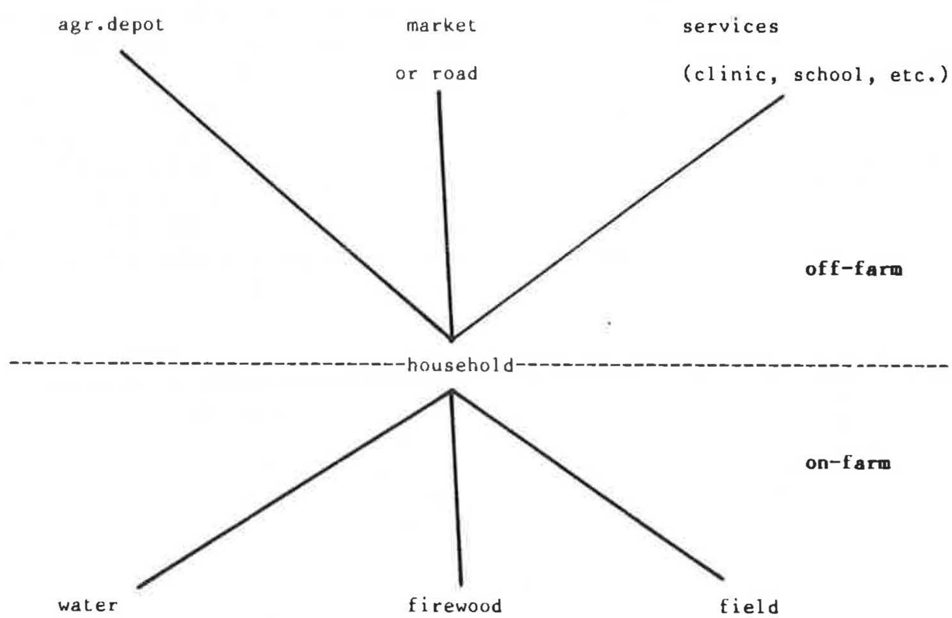


FIGURE 3 On- and off-farm transport destinations.

and below motorized vehicles, e.g., sledge, wheelbarrow, bicycle).

*On-Farm Transport*

**Agriculture** The majority of the rural population are small farmers. Thus trip patterns, which are the result of activities that pertain mostly to land cultivation, are determined primarily by the location of farm and fields. The determinants of demand for transport are as follows:

*Distance from Farm to Field (Table 2)* Cassava and sorghum fields are always located close (within a few hundred meters) to the farm. Transport of these subsistence crops is nearly always undertaken by women, using head-loading.

TABLE 2 DISTANCE FROM FARM TO MAIZE FIELDS

| Distance (m) | Percentage of Farms |
|---|---|
| <100 | 18 |
| 100–500 | 33 |
| 500–1000 | 24 |
| 1000–2000 | 12 |
| 2000–3000 | 13 |

*Ownership and Availability of Transport Means* In Table 3, the modal choice of farm to field and return trips is given for transport of maize input and output. All farmers who own wheelbarrows use them for transport of unhusked maize from field to farm. The average farm-to-field distance for this group is about 400 m. Shoulder-loading is practiced by farmers who do not own any other means of transport and do not want to rent any for these trips. In addition, the roughness of ploughed fields and the insufficient width of tracks hamper the use of some intermediate means of transport.

TABLE 3 MODAL CHOICE FOR FARM TO MAIZE FIELD TRIPS

| | Percentage of Transport Trips | |
|---|---|---|
| Transport Means | Input | Output |
| Sledge | 29 | 29 |
| Bicycle | 8 | – |
| Tractor | 4 | 4 |
| Oxcart | 17 | 17 |
| Wheelbarrow | 17 | 25 |
| Shoulder-loading | 25 | 25 |

*Required Quantity of Input (Seeds, Fertilizer)* It is estimated that about 450 kg of input are required for the cultivation of 1 ha maize. Average hectarage under cultivation ranges from 1 ha to 1.5 ha. For cultivation of traditional crops, no significant input is required.

*Frequency of Cultivation and Seasonal Peaks* In general, maize is harvested once a year, with transport peaks during July–September. The cultivation of traditional crops does not produce transport peaks.

*Quantity of Output* An average farmer in fertile areas transports up to 4 000–5 000 kg of unhusked maize per year from field to farm. Maize is usually husked on the farm.

**Firewood** A present, there is no shortage of firewood in Western Province. Distances are mainly determined by land ownership because firewood can only be collected from an individual's own land (see Table 4). Collection of firewood is done by men, women, and children. Men carry the larger poles; women and children carry bundles of smaller branches. Firewood collection is often combined with a trip from the field. The frequency varies from daily to twice a week. Occasionally, the sledge is used for this purpose. Firewood consumption for domestic use is estimated at 3 kg per person per day (pppd).

TABLE 4 DISTANCE TO FIREWOOD LOT

| Distance (km) | Percentage of Farms |
|---|---|
| <1 | 34 |
| 1–2 | 42 |
| 2–3 | 12 |
| 3–4 | 7 |
| 4–5 | 3 |
| >5 | 2 |

**Water** Fetching water is a task typically performed by women and children. Water is fetched 2–3 times per average day; 15–20 liters are carried each trip. Average water consumption is about 15 liters pppd. Table 5 shows that people who live relatively far from water sources (say, more than 500 m) use a different water source during the wet season. Obviously, the distance to the water source is a major problem for these people. The water is always carried by head-loading, using steel buckets or calabashes (dried, hollowed-out gourds).

TABLE 5 DISTANCE FROM FARM TO WATER SOURCE DURING DRY AND WET SEASONS

| | Percentage of Farms | |
|---|---|---|
| Distance (m) | Dry Season | Wet Season |
| <100 | 35 | 35 |
| 100–250 | 12 | 12 |
| 250–500 | 12 | 15 |
| 500–1000 | 20 | 35 |
| 1000–1500 | 6 | – |
| >1500 | 15 | 3 |

*Off-Farm Transport*

**Agriculture** Transport of cash crops from the farm to the buying center (established by the Primary Cooperative Society) is generally undertaken by the farmer. In some areas, the Primary Cooperative Society has decided to build collection points (Figure 4). These simple storage facilities are provided if distances to the nearest buying center are considered too great (say, more than 10 km). The maximum distance to be covered by an ox-drawn sledge is estimated at 20 km per day. Either the

| | |
|---|---|
| farmer | June, July |
| \| | |
| (collection point) | July, August |
| \| | |
| buying center | July, August, September |
| \| | |
| (intermediate depot) | August, September |
| \| | |
| district center | August, September, October |

**FIGURE 4 Transport chain in official maize marketing, by time of year.**

Western Province Cooperative Union or the Primary Cooperative Society transports the bags of maize from the collection points to the buying center and eventually to the district center.

Supply of input (seeds, fertilizer, empty grain bags) is influenced by a lot of external factors and is thus often inconsistent. On the other hand, application of farming inputs is often very time-sensitive. During periods in which these supplies are vital, transport peaks occur, and the transport capacity may be too low. This is a source of many problems because farmers often do not own any transportation and have to rent or borrow on an ad hoc basis. In general, a more efficient use of oxen and sledge or oxcart is achieved through the current private renting out of this equipment among farmers. The use of sledges prevails for these trips (Table 6).

TABLE 6 MODAL CHOICE OF TRIPS TO COLLECTION POINTS

| | Percentage of Transport Trips | |
|---|---|---|
| Transport Means | Input | Output |
| Sledge | 61 | 60 |
| Bicycle | 4 | – |
| Tractor | – | 5 |
| Oxcart | 20 | 21 |
| Wheelbarrow | 15 | – |
| Minivan | – | 9 |

**Social Contacts** Social contacts include the following:

*Education* Long walking distances cause fatigue among pupils, resulting in absence (Table 7). The journey to school must sometimes begin while it is still dark, which is considered disadvantageous. This occurs because children attend school in shifts, so school starts early.

TABLE 7 DISTANCE FROM FARM TO SCHOOL

| Distance (km) | Percentage of Farms |
|---|---|
| <1 | 11 |
| 1–5 | 39 |
| 5–10 | 42 |
| >10 | 8 |

*Medical Treatment* In the case of acute illness, a patient cannot wait for a convenient transport opportunity. Consequently, patients are often transported under miserable circumstances (back-loading, wheelbarrow) over long distances (Table 8) or die along the road while waiting for transport.

TABLE 8 DISTANCE FROM FARM TO RURAL HEALTH CENTER

| Distance (km) | Percentage of Farms |
|---|---|
| <1 | 11 |
| 1–5 | 36 |
| 5–10 | 33 |
| 10–15 | 15 |
| >15 | 5 |

*Visits to Relatives and Friends* Visits to relatives and friends are very important because these trips are often the only way to obtain information and spend leisure time.

### Comparison of On- and Off-Farm Transport

To compare the relative shares of on- and off-farm transport in local-level transport, determinants like total distances covered, travel time, quantities of transported goods, or derived magnitudes can be used. The following example involves an average farmer in the Western Province whose only cash crop is maize. The following assumptions are made:

- A household of five people: one male adult, one female adult, and three children;
- Total hectarage of maize is 1.2;
- Husking of maize is done on the farm, and 2 kg of maize in the husk yields 1 kg of husked maize;
- Agricultural input (seeds and fertilizer) weighs 300 kg and must be transported from selling point to farm (10 km) and from farm to field (2 km);
- Total output of unhusked maize (subsistence and surplus) is 4000 kg, which must be transported from field to farm, and total husked maize surplus has to be transported from farm to selling point;
- Water usage is 5 kg pppd, and the water source is 0.5 km from the farm; and
- Firewood usage is 3 kg pppd, with the source 2 km from the farm.

The transport flow per year may be calculated as follows:

*On-Farm*

| | |
|---|---|
| Water: 5 people * 5 kg * 365 days = | 9 125 kg km |
| Firewood: 5 people * 3 kg * 365 days = | 5 475 kg km |
| Agricultural inputs: 300 kg * 2 km = | 600 kg km |
| Agricultural outputs: 4 000 kg * 2 km = | 8 000 kg km |
| Total, on-farm | 23 200 kg km |

*Off-Farm*

| | |
|---|---|
| Agricultural inputs: 300 kg * 10 km = | 3 000 kg km |
| Agricultural outputs: 1 800 kg * 10 km = | 18 000 kg km |
| Total, off-farm | 21 000 kg km |

This example shows that the share of on-farm transport is quite large. Still, some other factors must be considered, because this example is incomplete. For example, transport of subsistence crops like cassava is not taken into account (this is nearly always on-farm transport). Also, only goods transport is considered. The distances covered for social contacts (for example) are not taken into account. Finally, the aggregation of transport activities to kilogram kilometers does not reveal the differences in consumed time and energy. For example, transport of 1 kg km water by a woman who uses head-loading is far more arduous than transport of 1 kg km maize by oxcart, a task done by men. To solve this problem, a (subjective) weighing factor could be applied. It is likely that this change in estimation technique would stress the significance of on-farm transport.

The relative share of on-farm transport in the example is quite large. On-farm transport is, as already stated, characterized by large involvement of women, and thus women are contributing significantly to transport activities in general. In comparison to off-farm transport, on-farm transport is less sensitive to external factors. For off-farm transport, the time of arrival of input at the selling point, the hiring or borrowing of transport means, and other factors should be taken into account, but on-farm transport is usually undertaken on foot and is thus within the power of the farmer himself (*3*).

## CONCLUSIONS AND RECOMMENDATIONS

In general, agricultural transport activities are influenced by the kind of crops cultivated. The introduction of maize and rice as cash crops (and consequently as staple crops) could have many unexpected and undesirable consequences, especially in regions where subsistence farming predominates. In contrast to a traditional staple crop like cassava, maize and rice require excessive labor and timely transport during specific, brief periods. These requirements do not fit in well with other tasks that have to be performed daily on a Zambian farm.

Within Western Province, Zambia, the low availability and variety of intermediate transport means is a more pressing problem than the lack of road infrastructure. Traditionally, the responsibility for road construction is in the hands of the government. The issue of improving the quality and availability of low-cost transport means could also be seriously influenced by government initiatives. These changes depend on the following:

- Level of local skills, which is a direct consequence of available educational facilities;
- Research into the use of appropriate, locally available materials;
- Support by the local administration in establishing (private) workshops;
- Economic viability of newly introduced techniques (prices should be subsidized only to a small extent by donor aid);
- Government encouragement of provision of some technologically advanced items (e.g., bearings, pneumatic tires, spoked wheels, axles) because these components enable local manufacturers or even the farmers themselves to build vehicles with locally available materials, as has been done in the People's Republic of China and Vietnam.

For Western Province, Zambia, some specific remarks can be made. First of all, attention should be paid to the current low educational level of the few craftsmen available. Local craftsmen must be trained for manufacturing (or assembly), maintenance, and repair of transport means. This work could be combined with provision of repair facilities for farming implements. To overcome the remigration problems that have been experienced at training centers, training should take place within the area that is to be served.

The final goal should be the establishment of private rural workshops. Pairing workshops with the activities of cooperatives is not recommended because there is no direct relationship between the membership fee and the advantages of membership (e.g., maintenance and repair facilities). In addition, supervision might be difficult, and abuse of facilities could occur. In general, it appears that private entrepreneurs have more incentives to keep facilities in good condition.

The initiatives to establish workshops should focus primarily on high-potential areas. Training courses on carpentry, blacksmithing, welding, and bicycle repair should start on a very small scale because the actual and future demand for services cannot be estimated with any degree of accuracy.

Animal draught power seems to be the most viable solution in areas that face a deteriorating supply of motorized transport. Oxen should be owned privately. Experiments in other parts of Zambia have shown that communal use of oxen is not feasible. Initiatives for the hiring out of oxen on a commercial basis should be encouraged because this practice will reduce the need for credit for the purchase of oxen by individual farmers.

The present low availability of scrap axles and tires is constraining the manufacturing of oxcarts within Western Province. Replacement of heavy scrap axles by locally manufactured wooden axles, which will eventually need wooden wheels, will cause problems in loose-sand areas. Although oxcarts have proved to be useful, encouragement of oxcart use (e.g., by credit supply) should be undertaken carefully because a sufficient supply of spare tires and repair facilities at rural workshops is a prerequisite. If current constraints on extending oxcart use prevail, a more extensive use of sledges is foreseen. For sledges, the present low availability of chains, used in linking sledge and yoke, is the only problem that requires attention.

Decisions on improvements of bicycle quality and prices are being made at a national level. The only local manufacturer of bicycles is an organization that is state-supported and thus has no incentives to improve quality. Bicycle repair facilities should be included in the establishment of rural workshops. These facilities should be combined with the retailing of bicycles, spare parts, inner tubes, tires, patches, and adhesive, as well as some basic tools (wrenches). In addition to their use as personal transport, bicycles could be very useful for on- and off-farm transport activities. Bicycles specifically designed for load carrying would be very useful in hard-sand areas of Western Province (*7*).

The construction of wooden wheelbarrows on an experimental basis is recommended. Wheelbarrows could be made entirely of locally available wood. A wheelbarrow with an open platform would ease transport of bags of agricultural input and output and loads of firewood. Wooden wheelbarrows are already being constructed in other parts of Zambia for K 60. As a comparison, a steel wheelbarrow costs K 310 (1986 prices).

If the condition of the road infrastructure within Western Province is examined, the following conclusions emerge:

- The density of the road network is sufficient;
- The quality of the roads is only low in loose-sand areas; and
- Maintenance activities are scarcely being carried out.

Bridges are often bottlenecks in road infrastructure. Maintenance funds could be raised by taxes on agricultural in- and outputs. These funds, which would be controlled by the cooperatives, should be distributed to local administrators.

Table 9 is based on findings in Western Province. The table presents allowed maximum distances to particular activity locations in combination with frequency and weight of load. In addition, an attempt has been made to rank the activities in terms of difficulty and time consumption; thus fetching water is the most arduous task. Fetching water also appears to be the most arduous and time-consuming task performed by women. In general, women have less access to transport means and are therefore confined to head-loading. The use of intermediate means of transport will be a definite benefit to women only in those tasks presently carried out by both men and women (firewood transport and farm-to-field transport for both cash and subsistence cropping). Improvements in water transport can only be achieved by a reduction of the distance to the water source. Thus the introduction of improved boreholes, which might result in longer haulage distances, does not seem viable.

TABLE 9 MAXIMUM ALLOWED DISTANCES IN ACTIVITY PATTERN OF RURAL HOUSEHOLD

| Activity | Frequency (trips per year) | Load (kg) | Maximum Allowed Distance (km) |
|---|---|---|---|
| Fetching water | 700–1,000 | 15 | 0.5 |
| Farm to field transport | 300–500 | 10–100 | 5 |
| Collecting firewood | 100–150 | 5–30 | 5 |
| Off-farm transport of agricultural input and output | 5–50 | 50–500 | 10 |
| Services | 2–10 | – | 10 |

NOTE: Tasks are ranked in terms of difficulty and time consumption; fetching water is the most arduous.

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