vehicle-h with the displacement of 85 households are considered by the decision maker as equally desirable (all in region P). However, by using the information provided by the multiobjective trade-off curve, he or she can realize that the first of these three alternatives (point 1) is dominant with respect to the other two objectives and is therefore superior to the other two.

CONCLUSIONS

A new approach to the HNDM that allows comparison of network alternatives on the basis of multiple incommensurable objectives with different degrees of importance was presented. The goal-programming approach is capable of solving the multiobjective highway network design problem in a speedy and efficient manner. Furthermore, it could be used to generate multidimensional trade-off curves that provide additional important information to that provided by two-dimensional trade-off curves derived from the linear programming model.

The goal-programming approach was shown to overcome some serious limitations of linear programming. In linear programming, a solution that violates one or more of the constraints is termed infeasible. It is easy to realize that this type of conclusion provides no useful information and can often be considered misleading. For example, a basic assumption of the HNDM is that interzonal demands are given with certainty. In reality, predicted demands are subject to great uncertainty. Consequently, certain combinations of prediction errors can result in an infeasible solution and no further information is provided to the decision maker.

The budget objective is formulated in the linear programming model as a constraint. There are two serious problems with such a formulation. First, the decision maker does not have an a priori knowledge of the investment required to satisfy the predicted demands. In fact, he or she would probably expect to obtain this information from the model. If the budget is set too low, it may result in infeasibility. Setting the budget too high to avoid infeasibility would lead to overconstruction and an unrealistic flow pattern. Second, the budget is not independent of the level of service in the network. In fact, the budget is determined to achieve a desired level of service or certain levels of other impacts. The goal-programming approach avoids these problems because aspirations about the level of service and other impacts can be specified and we are allowed to consider the budget as a nonabsolute objective.

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Abridgment

Development of Year-2000 Alternative Transportation Plans for the Delaware Valley Region

Thabet Zakaria

This paper discusses the concept and methodology used to develop long-range alternative transportation plans for the Delaware Valley Region. Four year-2000 alternative plans, including the no-build alternative, were formulated for simulation and evaluation. After a comprehensive evaluation of these alternatives, one of them will be selected and modified to be the year-2000 transportation plan. The alternatives were developed to achieve a set of regional goals prepared to deal with transportation issues and problems. The regional development pattern, travel demand and system deficiencies, short-range plans and programs, financial resources, administrative and legal requirements, and governmental and citizen recommendations were the major criteria considered in the formulation of the alternative plans. The alternatives were developed through an open two-way communication process between the staff of the Delaware Valley Regional Planning Commission and the various governmental agencies and private citizens involved in transportation planning. This process, which resulted in economical, feasible, practical, and implementable alternatives, could be applied successfully to any urban region in the country.

This paper discusses the concept and methodology used

to develop year-2000 alternative transportation plans for the Delaware Valley Region, which includes nine counties and three large cities in Pennsylvania and New Jersey and has a population of more than 5 million. The year-2000 planning effort of the Delaware Valley Regional Planning Commission (DVRPC) will replace the 1985 land use, water, sewer, open space, and transportation plans that were adopted in 1969 (1). Only a few of the facilities proposed in the 1985 transportation plan have been constructed and opened to traffic. This plan is currently under major review due to social, economic, and environmental changes that occurred in the last decade.

METHODOLOGY FOR THE DEVELOPMENT OF ALTERNATIVE PLANS

Rational planning requires that a wide range of alternative plans be developed, tested, and evaluated to determine their impacts on land use, traffic patterns, and the natural and social environments. After a comprehensive evaluation of these alternatives, one is usually selected for programming and implementation (2-4).

Many alternatives can be formulated on the basis of a given set of alternative land use plans and transportation projects and policies. When the number of transportation projects and policies becomes large, a great number of possible combinations can be obtained. Because of the limited budget and time available to simulate travel demand and to evaluate alternative plans, DVRPC developed only four alternatives. The no-build alternative is considered one of these alternatives.

A discussion follows of the activities performed by DVRPC to develop the alternatives, which were endorsed unanimously by the DVRPC board in December 1978 (5). The following activities were accomplished.

Discussion and Definition of Transportation Problems and Needs

To obtain a general consensus on regional needs and preferences, DVRPC conducted a conference on regional planning issues in 1975. The participants were citizens, political leaders, technicians, university professors, and public and private officials of diverse backgrounds.

The conference centered on planning issues pertaining to society, land use, environment, and transportation. Examples of such issues and problems are safety and security, traffic congestion, provision of public transportation service, air and noise pollution, parking, energy and future technology, capital cost and financial resources, and system operating and maintenance cost.

Consideration of Governmental Recommendations

As in other metropolitan areas, the state, county, and city governments are involved in transportation planning and operation. The governments, which are represented by the 18 members of the DVRPC board, make the final decisions on DVRPC plans and programs.

To obtain government inputs on the alternative plans, DVRPC staff met individually and collectively with city and county planning commissions, transit operating agencies, state departments of transportation, and turnpike and bridge authorities. These meetings and additional correspondence between DVRPC staff and these agencies resulted in a set of specific transportation policies and facilities for each of the alternative plans.

Figure 1 shows the decision-making process followed in the development of year-2000 alternative plans. This process is open and has two-way communication between the concerned parties or agencies.

Consideration of Citizens' Recommendations

Citizen participation is a prerequisite for successful transportation planning and implementation. The DVRPC citizen participation program has been expanded to accommodate citizen inputs in the various steps of planning. As shown in Figure 1, citizen inputs into the alternative plans were obtained from the county citizen forums and the year-2000 regional transportation advisory committee, which has more than 100 members and meets monthly at the DVRPC offices.

County citizen forums are held periodically in each of the region's nine counties. The forums involve representatives of county and local citizen groups and interested individuals. At the regional and county citizen forums, citizens were asked to review and comment on DVRPC work and to provide their recommendations concerning any specific transportation policy and facility that should be included in the alternative plans.

Preparation of a Set of Transportation Planning Goals

After the definition of transportation issues and problems, a set of goals and objectives for the development and evaluation of alternative plans was prepared. It was decided to use the goals for developing the alternatives for testing and evaluation. These goals reflect not only transportation concerns but also socioeconomic and environmental considerations expressed in the statement of transportation problems and issues. The goals and objectives were discussed with technicians and citizens at the regional and county levels.

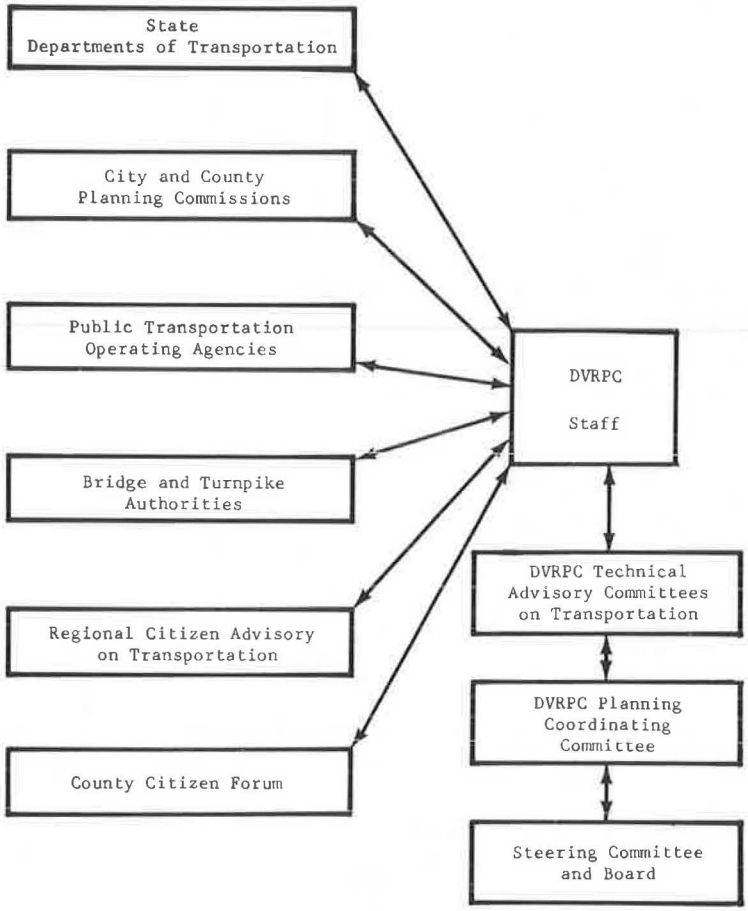
Consideration of the Regional Development Guide

The regional development guide (RDG) includes the policies adopted by the DVRPC board concerning the magnitude and location of future regional development (6). The RDG was adopted after 10 scenarios of regional growth had been screened by the DVRPC board and citizens. Each scenario framed a set of policies that responded to the regional issues. After considerable discussion, the DVRPC board selected four scenarios (futures) for further study.

These scenarios were studied for their implications and consequences for land use, open space, housing, transportation, water quality, air quality, energy, and environmentally sensitive areas. In the transportation study, sketch-planning models were used to study their impacts. Each scenario was tested for its effect on the existing transportation system. Areas in which congestion could be expected were identified, and approximate measures of the cost required to eliminate these traffic problems were prepared.

After considerable discussion of the implications of the four scenarios, the DVRPC board adopted the RDG in 1977. Moderate rates of growth in the regional population and employment are projected in the RDG. Future growth is encouraged to locate in and around the existing urban and suburban centers, which have been declining. Some recentralization of land uses within the urban area is also encouraged. The expansion and improvement of the existing transportation system is encouraged to serve the type of land use development described in the RDG.

Figure 1. Decision-making process for the development of year-2000 alternative plans.



Analysis of Current and Future Travel Demand on the Existing Transportation System

The analysis of current and future traffic on the existing system (no-build alternative) indicates the location and magnitude of highway and transit deficiencies. The information obtained from this traffic simulation is used to develop alternative highway and transit solutions to such traffic problems.

The analysis of highway volumes and capacities resulted in the identification of highway links that are, or will be, congested by the year 2000. The analysis of future transit demand indicates whether there is a need for additional public transportation facilities and service. Such a service will be required if transit trips increase significantly due to regional growth or if there is no service at the present time (7).

Coordination of Year-2000 Alternatives with Short-Range Plans and Programs

Although the target year for the alternative plans is the year 2000, DVRPC staff gave increased emphasis to short-range projects that are included in the transportation system management element (TSME) and the transportation improvement program (TIP). Such short-range projects have been under consideration for a number of years and have been studied many times. Some of them have reached the implementation stage and are under construction or have been committed for construction in the near future. Most of these projects, however, are small, low-capital-intensive projects intended to improve the existing transportation service.

These projects and other missing highway or transit links that complete the regional transportation system are generally committed for construction and are included in the year-2000 alternative plans. In addition, DVRPC considered the recommendations of past transportation studies in the formulation of year-2000 alternative plans so that no major conflict between the regional plan and local plans will arise in the implementation stage.

Analysis of Cost and Financial Resources

The analysis of financial resources is perhaps the most important factor that should be considered in the development of alternative plans. This analysis at DVRPC has indicated that capital for constructing and operating transportation facilities will continue to be increasingly scarce in the future (8). Discussion with federal, state, and local officials responsible for transportation programming and budgeting pointed out that the funds anticipated to finance long-range transportation projects will fall short of the region's expected needs. They based their recommendations on the fact that the escalation of construction cost of the programmed facilities and the cost committed to operate and maintain the existing system will consume all of the anticipated funds. Further, other urban services will be competing highly with transportation for scarce financial resources.

Consideration of Legal and Administrative Requirements

Legal and administrative requirements are important in

the development of alternative plans since they indicate the types of transportation facilities and policies that are feasible. Federal, state, and local requirements are especially critical to the implementability of the planning program. Many federal requirements, mandated by the U.S. Department of Transportation (DOT) and U.S. Environmental Protection Agency (EPA), limit the choices of transportation alternative plans and projects. DVRPC analyzed such regulations and guidelines so that the alternatives recommended will be feasible and implementable.

CHARACTERISTICS OF THE ALTERNATIVE PLANS

In addition to the no-build alternative, DVRPC staff developed three alternative plans based on the factors outlined previously in this paper. Before they were endorsed by the DVRPC board, the alternatives were defined, mapped, and presented to the various technical and policy committees and citizens shown in Figure 1. Some modifications were made to the initial alternatives after the first round of discussion and coordination. The alternatives endorsed are briefly described below (2).

No-Build Alternative

This alternative assumes no major new projects and consists of the existing facilities that were open to traffic in 1978. To operate the existing transportation system at a minimal level of service, some essential improvements are provided, such as the following:

1. Highway and bridge replacement and rehabilitation,
2. Restoration and resurfacing,
3. Transit vehicle replacement, and
4. Minor station improvements.

These improvements are also included in the other alternatives. This alternative does not provide an acceptable level of service. It is analyzed mainly for the purpose of formulating and evaluating the other alternatives.

Alternative 1

This alternative includes the transportation facilities included in the recent editions of the TIP. This alternative assumes that the TIP improvements and recommendations may take up to 22 years to complete rather than the 6 or 12 years scheduled in the TIP. This conservative view is generated from the current analysis of anticipated funding to build and operate new facilities. TIP projects are included in this alternative because they complete the missing links in the regional transportation network and improve the operation of the existing system.

Alternative 2

This alternative includes small projects to manage and improve the existing transportation system for servicing the year-2000 travel demand. It also includes the committed major facilities to complete the missing highway and transit segments that are essential to traffic flow and passenger service. Most of the facilities in this alternative are proposed to improve the operation of the existing highway and transit systems. Alternative 2 includes fewer new highway and transit facilities than alternative 1 because low-capital-intensive projects are used to serve future travel demand. Therefore, the level of transportation service provided by this alternative will be lower than that provided by alternative 1.

Alternative 3

This alternative is designed to provide alternative transportation service to that recommended in the other alternatives at some areas and corridors. Alternative 3 replaces some major facilities recommended in alternative 1 with less-extensive projects. It also includes other needed highway or transit facilities not recommended in the other two alternatives. This alternative will result in testing and evaluation of the impacts of these new facilities on the transportation system. Like alternatives 1 and 2, this alternative includes the committed facilities and other small projects to improve the efficiency of the existing transportation system.

Summary

Each of the alternative plans consists of five elements:

1. Existing transportation system in 1978, except for those facilities proposed for abandonment;
2. New freeway and transit facilities that are under construction or recommended for construction;
3. Recommended highway and transit improvements, such as arterial widening, construction of new arterials, electrification of rail lines, improvements to transit stations, and purchase of new transit cars;
4. Other improvements, such as rehabilitation and restoration of highways, repairs of critical bridges, fringe parking facilities, Traffic Operations Program for Increasing Capacity and Safety (TOPICS) projects, highway safety projects, replacement of old buses and automobiles, improvement to rapid-transit-line power equipment, and replacement of old railroad cars (most of these high-priority projects are not listed in year-2000 plans, but a total sum of money is allocated for such small improvements on the basis of the TIP cost estimates; these improvements are considered an essential element of any plan); and
5. Additional regional highway and transit improvements that are limited to turnpikes, toll bridges, bicycle projects, and National Railroad Passenger Corporation (Amtrak) lines and stations.

Table 1 (2, tables 3 and 4) provides a summary of the total capital cost for highways, transit facilities, and various transportation improvements for each alternative plan. It also shows the annual operation and maintenance cost required to maintain the highway and public transportation system and to provide adequate transportation service for each alternative plan. The capital cost of all alternatives was found to be within the range of anticipated financial resources.

The development of DVRPC alternatives was a lengthy process. It took nine months and involved many meetings and discussions with the states, counties, funding agencies, transit operating agencies, and citizens. Each group provided specific suggestions and recommendations for inclusion in the alternative plans after discussion with DVRPC about transportation problems, goals, future trends, and other important factors. Staff reviewed all inputs and incorporated the recommendations that fit the criteria for plan formulation. All suggestions and recommendations not included in the alternatives were listed with explanations for their rejection and were discussed with the concerned organization before arriving at a final decision.

The alternatives were developed through an open and

Table 1. Capital and operating-and-maintenance costs of year-2000 alternative plans.

Item	Alternative[a] ($000 000)			
	No-Build	1	2	3
Capital cost of highway improvements				
New freeways		1431	674	1417
Arterials		370	251	644
Other	618	838	838	838
Total	618	2639	1763	2899
Capital cost of public transportation improvements				
New facilities		1647	181	1093
Facility renovation		489	464	492
Other	672	973	973	973
Total	672	3109	1618	2558
Total capital cost	1290	5748	3381	5457
Annual operating and maintenance cost	345	393	389	397
Capital cost of additional region-wide improvements				
Bicycles	5.7	5.7	5.7	5.7
Turnpikes		70.7	137.6	70.7
Calhoun Bridge				16.6
Amtrak	210.8	210.8	210.8	210.8

[a]Costs are in 1977 dollars.

participatory two-way communication process between DVRPC staff and the various groups that are affected by transportation decisions. DVRPC prepared the documents and guidelines that are essential for conducting meaningful, rational, and organized discussions among the various groups involved in the planning process.

The reader may have observed that all DVRPC alternative plans include the following common elements.

Intensive Improvements of the Existing Transportation System

All alternatives (as shown in Table 1) include many small projects to improve the existing highway and transit systems. Such projects are given high priority and will be recommended in the final plan. Without such improvements the existing system will not function in the Delaware Valley because it is old and deteriorating. Also, it is incomplete and uncoordinated.

All Modes of Surface Transportation

None of the alternatives is highway- or transit-oriented, as was usually the case in past transportation planning studies. The alternatives developed are balanced and provide all modes of transportation service to all population groups in the region. All alternatives place some emphasis on the efficiency of the transportation system and energy consumption.

Small Transportation Projects as Well as Large Ones

As shown in Table 1, a sum of money is allocated for small projects although they are not specifically listed in the alternative plans. This is a departure from past regional transportation plans, including the 1985 DVRPC plan, which dealt mainly with major highway and transit facilities. As indicated in Table 1, the total cost of small (or other) improvements is considerable and should be accounted for in any long-range plan.

Short- and Long-Range Projects

Short-range projects should be included in the long-range plan because they are often as important as the long-range projects. Further, short-range plans and programs must be coordinated with long-range planning to obtain consistency in the transportation planning process and to recommend a reasonable implementation program.

Subregional and Regional Projects

Although they ensure system continuity and compatibility, the alternative plans are actually aggregations of subregional and regional improvements intended to solve local and county transportation problems. When accumulated, local problems become regional in scope. Generally, the negative impacts of transportation projects and improvements affect people at the local level. This does not mean that DVRPC alternatives are big municipal plans. Rather, local projects are considered in the development of regional plans that function systemwide. The impacts of any regional project will be considered in the evaluation of the alternative plans. This evaluation will result in recommending the most feasible and effective projects for inclusion in the final year-2000 plan.

Specific Projects and Flexible Solutions

Although the alternatives include many specific and well-defined projects, they are flexible and could be adapted to future changes in social and economic conditions and transport technology. The long-range plan that will be recommended on the basis of the evaluation of these alternatives will include specific projects and flexible strategies. The fixed or specific facilities are only those currently under construction or committed for construction in the near future to complete the missing links of the regional transportation network.

CONCLUSIONS

As part of the planning process to develop a year-2000 plan, DVRPC formulated a limited number of alternatives for testing and evaluation since it is impossible to predetermine the optimum plan. The regional transportation alternative plans were developed in cooperation with citizens, public transportation authorities, and planning departments of the various county and state governments.

The DVRPC alternatives were developed through an open and participatory two-way communication process between DVRPC and the various groups that are involved in the planning process. The role of DVRPC staff was to assist citizens and private groups and governments at all levels in defining transportation issues, problems, and goals and in developing alternative courses of action that are practical, economical, feasible, and implementable.

The alternative transportation plans were coordinated with land use and environmental plans to provide adequate service for all groups of the population. The alternatives consider short- and long-range solutions to the various transportation problems, within the constraints of financial resources and legal and administrative requirements. Further, the alternatives were defined to be specific with respect to projects and policies and yet adaptable to future changes in social and economic conditions that impact the transportation system.

The DVRPC approach to long-range planning can be applied successfully to any urban region throughout the country.

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Transportation Planning for Small Communities: Western Canadian Experience

S. Teply

The paper discusses the principles, constraints, and objectives of transportation planning in small communities. It compares some of the basic relationships derived in the United States with those found in several western Canadian communities. A synthetic planning process called the four-purpose trip generation and distribution model is described in detail. It uses an analogy approach by starting with estimated data found applicable in similar communities. In this way it avoids the costly and time-consuming data collection stage. The model is verified and calibrated after data processing. Computer traffic volumes are compared with traffic counts and, if necessary, the input values are adjusted. Sensitivity of the model to errors in the initial estimated data is analyzed in relation to the basic zonal land use characteristics (i.e., population and employment). A set of graphs is presented to expedite the calibration process. They relate the size of the unit outcome error (i.e., the difference between the computer and the surveyed traffic volume) to the required adjustment of initial estimates of trip purpose distribution.

Small communities in western Canada must determine the directions of their future development. Oil, gas, lumber, agriculture, and initial industrialization form the basis for a dynamic economy, especially in Alberta. The towns and cities have experienced a period of steady growth and strive to maintain a balanced development in all aspects of urban life in the future. This goal creates a need to plan ahead in order (a) to influence the demand, (b) to provide and control the supply of facilities, or (c) to do both. Planning in small expanding communities is rather difficult because even small unforeseen facilities, activities, or policies may have dramatic effects. The decision of a single industrial company to move into the area and locate at an opportune (yet at the planning stage unconsidered) location may make previous transportation plans invalid. The range of effects of such uncertainties is much more pronounced than in large, established cities.

THE PROBLEM

In the past 10 years, the trend in urban transportation planning has been to recognize the specifics of small communities and to adjust procedures and models accordingly. Identifying features of small communities may be listed as follows:

1. Population size of up to about 100 000 inhabitants [several research studies dealt with smaller (up to 50 000) or larger (up to 250 000) communities];
2. Economy usually pivots around several key activities;
3. Life-style in smaller communities is simpler;
4. Scenarios that are easily identifiable can cause significant migration into or out of the area;
5. Civic governments, both in elected and administrative portions, lack the expertise or resources for solving unusual problems (i.e., those that exceed day-to-day operations); and
6. Strain on financial resources, especially when considered on a per capita basis, is usually much larger because small communities cannot use the luxury of economy of scale.