THE COMMUNITY AGGREGATE PLANNING MODEL

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As urban transportation studies have begun to reevaluate existing system plans, planners have seen a need for more rapid and efficient tools for system evaluation. This need has been accentuated by increased public awareness of environmental and social consequences of transportation policy-related decisions and by the demand for increased citizen participation in the planning process. The community aggregate planning model attempts to fill this need by operating at the community level, by using easily obtained inputs, and by directly producing usable evaluation criteria. The model requires only simple inputs. System capacity is given by the freeway and surface-arterial lane miles (kilometers) in each community. Connectivity is assumed to be ubiquitous for arterials and is simply represented for freeways and expressways; there is no need to code extensive conventional networks. The only required demand measure is the number of vehicle trip ends in each community; this reflects externally derived transit-automobile modal-demand analysis. The model also combines, in one efficient computer package, modules that, with one pass, generate a regional system-sensitive vehicular travel demand, distribute the demand to the arterial and freeway systems in each community, and compute a full range of useful evaluation measures describing the direct and indirect consequences of the test alternative for each unit-community analysis. The output measures are comprehensible to planners, citizens, and decision makers and do not need intermediate summarization or interpretation. In addition, the model is designed to output performance measures for two alternatives simultaneously and thereby facilitates the comparative analysis of base and future alternatives.

•AS urban transportation studies have begun to reevaluate existing system plans, planners have seen a need for more rapid and efficient system evaluation tools. The community aggregate planning model (CAPM) fills the need for quick and easily used tools to assess the economic, social, environmental, and transportation system performance consequences of varied transportation system implementation and operating policies.

The role of planners has always been to provide information to decision makers about the consequences of their decisions; this has not changed. However, as citizens have become more directly involved in the planning process, the absolute number and variety of decision makers have vastly increased. Where at one time, the planner only had to provide information to a select group of knowledgeable public officials, he or she must now address the often broader concerns of a much larger and diverse group of citizens.

The recent emphasis on citizen participation in contemporary planning and on the concern given to broad quality-of-life and environmental issues provides a major challenge to transportation planners. Planners have found that it is no longer sufficient to analyze different transport alternatives on a purely engineering or economic basis and, therefore, have accounted for environmental and social impacts as well.

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However, the increase in the number of people involved and the concurrent broadening of the criteria by which transportation plans and policies are judged and the range of transportation options being considered have cast some doubt on the effectiveness of existing urban transportation planning tools. In many cases, although answers can be obtained through exercising traditional planning procedures, they cannot be obtained within the budget or time constraints under which the study is operating. There is a need for improved tools that are designed specifically to provide a first-cut evaluation of transportation proposals. There are three basic requirements for these sketch-planning tools. The first requirement is ease of input preparation. Because the standard mesolevel tools must necessarily produce detailed information, their inputs must also be detailed. This results in the provision of information describing physical facilities or operating policies that may be superfluous to the issues being addressed or the needed scale of the analysis. Another related problem with using current mesolevel tools in long-range system planning is that there must be a great deal of system detailing by planners and technicians before a proposed alternative can be defined for analysis. Because an alternative may be sensitive to these details, the planner may inadvertently bias the outcome of the analysis.

An additional characteristic of contemporary planning that supports the need for ease of input data preparation is the large number of alternative systems that must be considered. The large number of alternatives arising from increased citizen participation is also partly the reason for the second requirement of long-range system planning tools, ease of computer operation. Not only must a large number of alternatives be examined, but each one should also be evaluated relative to the varied future state. At the regional systems level, new facilities will have a profound effect on land use patterns and vice versa. It is, therefore, desirable to test each transportation alternative in conjunction with a variety of future land use configurations. Unless the evaluation tools are efficient in terms of setup time-cost and actual runtime-cost, the expense of making a large number of land use-transport alternative tests would be prohibitive.

The last requirement for sketch-planning tools is that their outputs be easy to understand and relevant to the evaluation task at hand. Because conventional mesolevel models were originally intended to directly produce only network link flow volumes, much planner interpretation is required to obtain information useful to the alternative system selection process. The time and cost of this interpretation, combined with the excesses of the other analysis steps, limit the number of alternatives that can be studied. This long interpretation time can also mean that results will not be available soon enough to allow meaningful input to or feedback from the actual decision process.

CAPM was designed as a sketch- or strategic-planning tool. As such, CAPM was developed specifically to eliminate the drawbacks and to conform to the criteria described above. CAPM represents an outgrowth of the transportation resource allocation study (TRANS) (1, 2, 3, 4, 5). TRANS is a national policy planning model designed to produce quick-response, multicriterion evaluation of transportation options. CAPM departs from TRANS in several respects; mainly it is designed to produce results meaningful for an individual urbanized area and communities within the area. As such, it is similar in concept to the work of Koppelman (6, 7) for the tri-state regional transportation study.

In CAPM, ease of input preparation, computer setup and operation, and output interpretation result in the ability to address the following kinds of issues at a community level:

1. Decisions about the location, magnitude, and function of urban transportation investments;
2. Formulation of highway operating strategies useful in obtaining environmental and system performance objectives, such as pollution abatement and fuel conservation; and
3. Examination of the transportation implications of future land development policies.

A major strong point of CAPM is that it can approach these issues with no need to code up extensive networks for computer manipulation. Highway capacity is input as the number of lane miles (kilometers) of arterials with freeway supply in each community represented by using route number to indicate lane miles (kilometers). This representation coupled with knowledge of the community in which various freeways intersect is used to describe high-level system connectivity.

Commensurate with this simple supply representation is the input measure of travel demand, i.e., community vehicle trip ends. These can be estimated directly from population and employment by using readily available factors or can emerge from a more rigorous multimodal demand analysis. In current CAPM development, land use and transit alternatives are evaluated through changing the vehicular trip ends input to the model. This enables the analyst not only to determine the highway requirements compatible with the particular option being evaluated but also to study changes in highway performance, costs, and impacts resulting from changes in land use activity or transit use.

As stated previously, CAPM is designed to directly produce easily understood transportation system performance measures. These include information such as description of the supply alternative being evaluated, including its cost, land consumption, residential and business relocations, system operating speeds and costs, air pollution emissions, and energy consumption. Based on development of these measures for a range of future alternatives and for the existing situation, within a limited time and with only limited expenditure of funds, CAPM should provide information useful to transportation decision making.

COMMUNITY AGGREGATE PLANNING MODEL SYSTEM

As shown in Figure 1, CAPM is composed of three basic modules: travel generation, travel distribution, and performance evaluation. In the travel generation module, a system-sensitive estimate of total regional vehicular travel is obtained. The travel distributor takes this regional total and allocates it to the arterial and freeway system in each community. Given the vehicular travel on, and capacity of, the highway system, the performance module computes a full range of community-level performance measures.

To gain a fuller understanding of this process, we should examine the basic assumptions and component modules of CAPM in more detail. Special attention will be paid to inputs from a user preparation point of view and outputs from the perspective of analysis utility.

Basic Relationships

CAPM represents a significant departure from conventional transportation planning procedures in that computerized networks are not used. This approach required the development of two basic relationships not present in the standard processes. The first of these deals with the direct determination of average speeds by facility type at a subarea level. It is generally agreed that the speed on a highway facility of a particular type and capacity is a function of the volume of traffic using the facility (8):

$$S_i = F\left(\frac{VMT_i}{CMS_i}\right) \qquad (1)$$

where

S_i = average highway travel speed on link i,
VMT_i = vehicle miles (kilometers) of travel on link i, and
CMS_i = capacity miles (kilometers) of supply for link i.

The weighted space-mean speed S can be found by weighting the speeds on individual links by the vehicle hours of travel on the links or by

$$S = \frac{\Sigma\,(S_i \cdot VHT_i)}{\Sigma\,VHT_i} \tag{2}$$

where VHT_i equals vehicle hours of travel on link i. However, Zahavi (9) and others have shown that, for a small area, S can be directly computed as a function of the total capacity of all links in the area and the total volume on those links by

$$S = F\left(\frac{\Sigma\,VMT_i}{\Sigma\,CMS_i}\right) \tag{3}$$

Zahavi (9) made no attempt to distinguish between freeways and surface arterials. For the purposes of CAPM, this differentiation has been made, and separate functional relationships were developed for each. Figure 2 shows the forms these functions take. The horizontal axis is labeled demand-capacity rather than the traditional volume-capacity. This does not imply any computational change from accepted practice where volumes greater than capacity are often computed. Its use only reflects the idea that the actual volume of travel does not exceed the capacity but rather that more vehicles wish to use the system in a given amount of time than can be accommodated. For such situations, the speed estimates reflect the excessive demand. The freeway curve shown is for a speed limit of 60 mph (96 km/h). To compute the curve for any speed limit, the equation used is as follows:

$$S = \frac{3{,}600}{K_1 e^{K_2(d/c)} + \frac{3{,}600}{S_o}} \tag{4}$$

where

S = average speed in miles (kilometers) per hour;
S_o = speed limit (free-flow speed) in miles (kilometers) per hour;
K_1 = constant, i.e., 0.4; and
K_2 = constant chosen so that the curve passes through 25 mph (40 km/h) at capacity [for 60 mph (96 km/h), K_2 = 5.35].

The surface arterial curves shown are for a speed limit of 35 mph (56 km/h). The approach used in CAPM to estimate these curves is a slight modification of one that was developed for TRANS (10).

The second basic relationship used in CAPM deals with the direct estimation of vehicle miles (kilometers) traveled (VMT) by facility type for a subarea. To make such an estimate possible, a process was developed (11) that circumvented the need for network coding by making use of certain properties of highway systems and some assumptions about travel behavior. Basically, the processes suggest that

1. Because the surface arterial system is ubiquitous, travel from any point to any other point in the region is made possible.
2. In the absence of freeways, drivers will use the shortest distance route to make their trips.
3. If there are freeways, drivers will divert from the shortest distance path to the

Figure 1. Community aggregate planning model system.

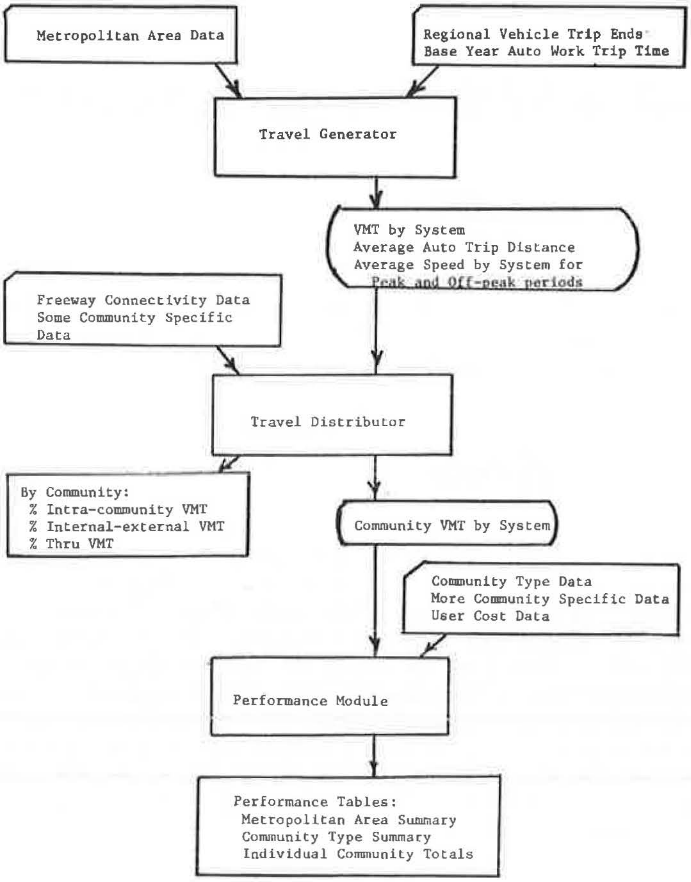
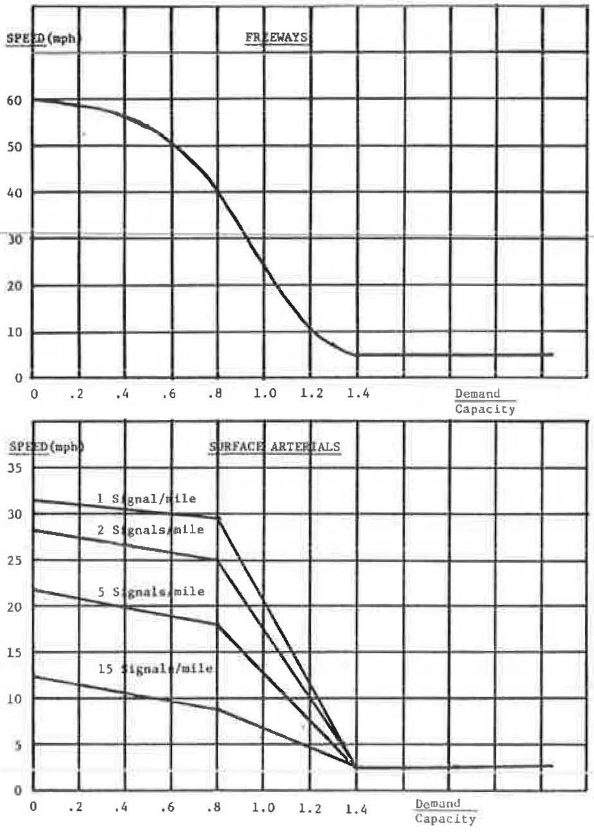


Figure 2. Speed versus demand.



extent that they perceive a time savings that is reflected in a time ratio diversion curve.

4. Availability of a freeway for a given trip can be ascertained if its position relative to the origin and destination of the trip is known; information about any intermediate points is not needed.

These ideas form the basis of the travel distributor.

Process

VMT Generator Module

The first module in the CAPM system (Figure 1) is a modified version of the DAM III analytic assignment model (12). Given highway system supply [miles (kilometers) of freeways, surface arterials, and locals], total vehicle trips, and average trip distance, DAM III enables one to compute the amount of travel on each highway facility type, commensurate equilibrium speeds, and average trip time. The total regional vehicular travel is fixed since both the number of trips and average trip distance are fixed. For CAPM, DAM III was modified to compute an average trip distance for the region sensitive to system speed. To accomplish this, the model is iterated on trip distance, assuming that, for the region, average over-the-road trip time for work trips remains constant regardless of long-term changes in the urban activity pattern or transportation system.

The nationwide personal transportation study tends to support the assumption of constancy in regional work-trip time (13). It shows that, for a sample of workers, more than one-half experienced no change in work-trip time over a 5-year period and that the number with increased trip time was essentially balanced by those with decreased trip time.

The average work-trip distance is computed by multiplying average highway speed at equilibrium by the assumed constant input average work-trip time. Finally, the average trip distance for nonwork trips is estimated by using the relationship shown in Figure 3, which was developed from transportation study data from 15 metropolitan areas. The two trip distances are then weighted to produce a regional average trip distance. Multiplying this value by the total number of trips generates a total VMT that is sensitive to system speeds. The areawide functional split of travel among freeways, surface arterials, and locals and regional system speeds is also estimated, though not used explicitly.

Travel Distributor Module

The travel distributor, which determines how much travel is on the respective systems in each community, is discussed below. The description explains the basic components of the process and how they fit together and does not completely present the details of the analysis, which can be found elsewhere (11).

Most basic to the whole approach is the exponential trip distance probability assumption, which states that trips distribute themselves over a region such that

$$P_i = e^{-x/\bar{x}_i} \tag{5}$$

where

P_i = probability of traveling a distance x or greater given the trip end is in community i, and
$\bar{x}_i$ = average trip distance of trip ends in community i.

This relationship directly or indirectly uses a value of $\bar{x}_t$ developed from the travel generator estimate of regional average trip distance and the position of community i relative to all trip ends in the region to estimate the probabilities discussed below.

The analysis is conducted by dividing the travel with respect to a community into its three components: internal, internal-external, and through. Internal and internal-external (with respect to each community) travel is estimated by using the trip ends associated with that community. The probability of a trip being wholly within the community is calculated by using the above distribution and the area of the community. This probability is multiplied by one-half the total community trip ends (a trip has two ends) and then is multiplied by the estimated average trip distance for intracommunity trips to yield the intracommunity VMT. The probability of a trip being internal-external is equal to 1.0 minus the probability of a trip being intracommunity. This probability is multiplied by the total community trip ends, and the resultant number of trips (internal-external trips have only one end in the community) is multiplied by the computed average distance for the portion of the internal-external trips within the community to yield the internal-external VMT for the community.

The remaining type of trip associated with a community is the through trip, that is, a trip with neither end in the community. To estimate these trips, the concepts of shadow area and freeway connectivity are introduced. The concept of a shadow area is shown in Figure 4. Assuming straight-line travel, any trip leaving community X and destined for area S_{xy} must pass through community Y. Thus, S_{xy} is the shadow area for the community pair X and Y. By estimating the probability of a trip going from X to S_{xy}, one can estimate the number of trips through Y that emanate from X. However, if there are freeways in the communities neighboring Y, some trips might better be diverted from their straight-line paths and use the higher type of facility. The number of such trips is estimated by using the freeway connectivity of communities. By noting the presence of a given freeway route in two communities, one can determine the extent of such diversions and hence estimate freeway use and through travel. For example, if communities X and Y in Figure 4 were on the same freeway route, we could assume that there would be no loss of through trips to neighboring communities. There would, however, be an estimate, based on a time-ratio diversion curve, of how many trips would use the freeway versus the arterial street system. If the freeway were in a neighboring community of Y, but not in Y, then those trips that used the freeway to go from X to shadow area S_{xy} would become through trips to the neighbor of Y and not go through Y itself. By looking at all community pairs, one can estimate the through travel and functional split of that travel for a given community and the functional split of the internal-external travel discussed above. Through trips are multiplied by the estimated average trip distance for through trips taking place in the community in question to yield through travel.

By summing these three travel components, we have an estimate of a community's total travel and the split of that travel between freeways and surface arterials. Only one step remains, normalizing to ensure that the total areawide travel distributed to all communities equals the areawide total travel produced by the generator. This step is necessary even though the average trip distance output of the generator is a parameter of the distributor probability function because the trip distances used in the distributor are based solely on community area and do not include system sensitivity.

Performance Module

In the performance module, the direct and indirect impacts of an alternative are computed. Computation of the indirect impacts is based on the daily travel forecast by highway system and community passed from the travel distributor, but the estimation of direct impacts is based on information on new highway system capacity.

Direct costs include things such as construction and maintenance costs, vehicle operating cost, and residential and business relocations. In the calculation of construction costs, the base year system is compared with a future alternative to determine, for each community, how many lane miles (kilometers) of new freeways and surface arterials are to be constructed. These values are used in conjunction with rates of cost per lane mile (kilometer) for the relevant system additions to compute costs. Major reconstruction and basic maintenance costs are computed in a similar manner.

For an estimation of residential and employment relocations, the area taken for new right-of-way is computed based on the miles (kilometers) of new-system and average right-of-way width. Next, the community's net residential and employment densities are computed. Finally, based on the proportion of each freeway's right-of-way occurring in each of the two land use types, relocations are computed. This procedure is similar to that recommended by Klein (14).

The remaining direct cost, vehicle operating cost, and important indirect impacts, such as energy consumption and air pollution emissions, depend on operating speed. As was indicated previously, knowledge of the amount of travel and capacity, by system and community, allows computation of space-mean speeds. These speeds are, however, only useful for the estimation of impacts when they are representative of the speeds in a given community. To improve the likelihood of this situation, the CAPM performance module takes the daily travel forecasts from the distributor and breaks them down by time of day and direction of travel in a similar fashion to that used by TRANS (1). This temporal and directional disaggregation is accomplished by using factors input for each type of community. When the VMT by community, system, time, and direction are known, the respective demand-capacity ratios can be computed, and the speed relationships entered.

Given the speeds by system type, time period, and direction of travel for each community, performance curves are used, impacts obtained, and daily totals computed. The relationships used to estimate vehicle operating costs, fuel consumption, and pollution emissions have been developed for the base year and future year conditions for automobiles and trucks. They assume average highway and traffic characteristics normally found in large urban areas, such as highway grades and curvature, speed change cycles, stops, and vehicle age distributions. As such, they represent default or average value inputs that are taken from the results of national transportation needs and research studies. They can, however, be easily replaced if a user wishes to supply what is thought to be better information. Thus, the model system is fully operational for quick application and is readily adaptable to local situations that may differ from national averages.

Input

Because of some assumptions made in the travel distributor, the analysis seems to work best for areas of about 10 miles^2 (26 km^2). Communities are defined to be areas of about that size, although a range of 8 to 30 miles^2 (20 to 78 km^2) is tolerable. Effort should be made to have regular community shapes, i.e., approximately equal length and width.

To use the full CAPM system, one must supply the following data items for the base and future (analysis) year:

1. Description of the community,
2. Trip ends for each community,
3. Regional average work-trip time assumed constant over time,
4. Surface-arterial lane miles (kilometers) for each community, and
5. Description of the freeway-expressway system for each community.

Community Description

A short description for each community includes input specifying name and number, type (central business district, central city, suburb, rural), area, population, and employment.

Trip Ends by Community

Trip ends can be input in either of two forms: internal vehicle trip ends or total person trip ends. If total person trip ends are used, then transit trip ends and average automobile occupancy must also be input. For the analysis year, a transit person trip end estimate commensurate with the policies to be tested would be skimmed off this total person trip end estimate, and the result would be divided by an average vehicle occupancy. This average vehicle occupancy would also be a function of the policies under analysis. Truck trips are accounted for by inputting the percentage of VMT that is the truck VMT.

Base-Year Regional Average Work-Trip Time

As was discussed previously, regional average work-trip time is assumed to remain constant over time. If a value were not available for the base year, one could be approximated and the model run until the VMT estimate for the base year corresponded to the one that was known (e.g., from a highway-transportation needs study or traffic-counting program).

Surface-Arterial Lane Miles (Kilometers) by Community

For the base year, surface-arterial lane miles (kilometers) of system capacity could be measured manually by using a functional classification map that is skimmed from a computerized network or that is computed on a mileage density basis. This latter technique, appropriate when an analysis must be done in a hurry and no data exist, amounts to the measurement of the lane-mile (kilometer) density for selected areas within the given region and the application of these density factors to the areas of the various communities. For the best accuracy, a number of density measurements would be made for each major land use type (e.g., rural, suburban-residential), an average computed, and the appropriate factor applied to each community based on the predominant character of its development. For the future year, surface-arterial capacity would be equal to the base-year estimate plus the new capacity corresponding to the implementation-operation policy to be tested.

Freeway System Representation

For each freeway passing through or having an end in the community, the following information must be known:

1. Route number of the freeway;
2. State of freeway, existing or proposed;
3. Average number of lanes;
4. Length of the facility within the community; and
5. Land use along the freeway route.

Route numbers for a proposed facility being tested could be determined the same way as Interstate or state route numbers; i.e., a relatively straight route with no doglegs or abrupt turns would be assigned a single route number. For existing freeway facilities, the route numbers may remain whatever they actually are. In case of a beltway or other circumferential freeway, for a more accurate analysis, the length should be divided into sections. If the beltway is a continuous ring, then division would be into three sections; if it is not continuous, then division can only be into two sections. Each section should be assigned a different route number. The average number of lanes and the length of the particular facility for the base and future year are self-explanatory.

The land use along the freeway route specifies the percentage of residential or employment use for calculation of dislocations.

Other Data

For other data items, average value inputs, obtained from summaries of the various transportation studies, are available. These data items are input to CAPM by community type for groups of communities, rather than for individual communities, with similar characteristics. Data of this nature include construction costs, freeway ramp spacing, capacities, speed limits (free-flow speeds), temporal splits, and directional flow. The model is completely flexible on community type of aggregations, but most of the average value items have a CBD, non-CBD central city, suburb, and rural breakdown. Though these average value items allow CAPM to operate with little information preparation by the local agency, a more accurate use of the model would entail the local derivation of as many average value data items as possible. (CAPM data input formats are available from the Urban Planning Division, Federal Highway Administration.)

Output

The evaluation measures produced by CAPM are displayed in three tables based on geographical aggregations by individual community, community type (e.g., CBD, central city, suburb, and rural), and metropolitan area totals. Each table is divided into five categories as given in Table 1. Evaluation measures for the base year appear directly above these for the proposed alternative in the computer output and thus facilitate direct comparison.

APPLICATIONS AND RESULTS

CAPM currently exists as a computerized model, written in FORTRAN IV, that requires less than 190 K bytes of core and about 6 CPU min for execution on an IBM 360/65 computer to process an alternative for 100 communities. Pilot applications of the process are taking place in St. Louis, Missouri; Phoenix, Arizona; Baltimore, Maryland; and Cincinnati, Ohio. Currently, CAPM directly produces only highway impacts. The evaluation alternatives in these four cities will, however, include proposals encompassing various public transit schemes. To analyze such multimodal systems, one must externally estimate transit ridership in each community and then make the appropriate adjustment to the total community vehicular trip ends. Thus, the input to the model remains highway trip ends, but the highway impact implications of a proposed transit alternative can be evaluated. One possible means of estimating transit use at a level of aggregation commensurate with CAPM is the Urban Mass Transportation Administration macro manual transit sketch-planning tool (15).

Table 1 gives the CAPM model outputs; as stated earlier, these appear for the region as a whole, for community types, and for the individual communities themselves. Table 2 gives selected results for a metropolitan area; the base condition is compared to two proposed alternatives. Two things should be realized when Table 2 values are looked at: (a) The change in the number of trips is an input rather than an output of the model, and (b) the drastic drop in pollution between the base and either alternative is primarily caused by the assumption that legislated pollution emission standards for automobiles will, in fact, become a reality. As can be seen, alternative 2 results in speeds that are slightly better than those in the base year but that are significantly better than those expected from alternative 1. Thus, if system performance is the major concern, the second alternative seems clearly superior. Alternative 2 also shows lower amounts of pollution, fuel consumption, and annual fatalities than alternative 1. However, for 20 to 25 percent higher speeds and 2 to 6 percent less pollution and fuel use, 80 percent

Figure 3. Average automobile non-work-trip distance versus average automobile work-trip distance.

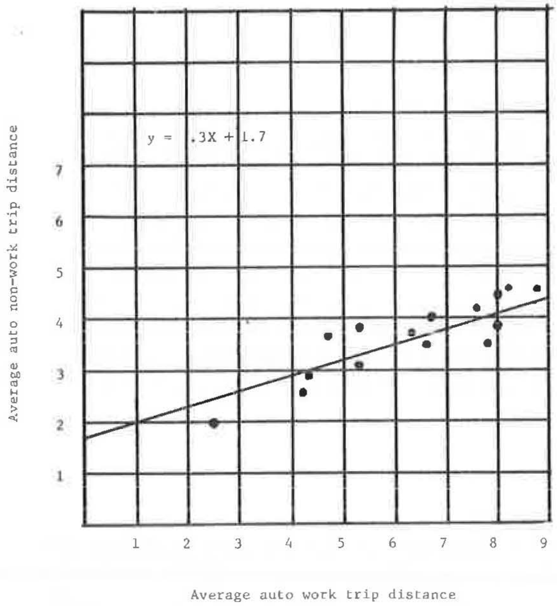


Figure 4. Shadow area concept.

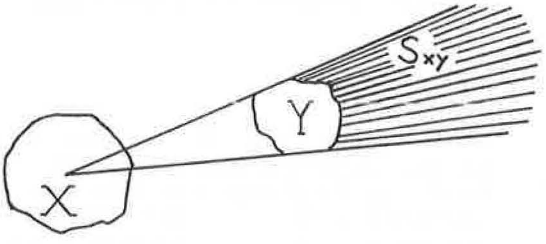


Table 1. Model evaluation measures.

Socioeconomic Data	Demand Data	Supply Data	Cost Data	Performance Data
Population Land area Employment Automobile ownership	Automobile driver trips Daily freeway VMT Daily surface-arterial VMT Daily local VMT Peak total VMT	Freeway lane miles Percentage of total capacity on freeways Surface-arterial lane miles Daily bus-miles Daily car rail miles	New freeway construction cost New surface arterial construction cost Freeway reconstruction cost Surface-arterial reconstruction cost Freeway maintenance cost Surface-arterial maintenance cost Total daily vehicle operating cost Daily accidents Number of jobs displaced Number of residents displaced Land consumed by new freeways Total annual fatalities Daily pounds of CO pollution Daily pounds of HC pollution Daily pounds of NO_x pollution Daily gallons of gasoline consumed	Daily average arterial volume-capacity Weighted average daily freeway speed Weighted average daily surface-arterial speed Weighted average daily local speed Weighted average daily total speed Peak-hour average freeway speed Peak-hour average surface-arterial speed Peak-hour average total speed Daily total vehicle hours of travel Daily average trip time

Note: 1 mile = 1.6 km. 1 lb = 0.45 kg. 1 gal = 3.8 l.

Table 2. Selected model outputs for metropolitan area.

Output Measure	Base Condition	Alternative 1	Alternative 2
Total daily automobile trips	3,138,200	5,406,800	5,050,800
Total freeway lane miles	576.3	1,189.0	1,588.5
Total surface-arterial lane miles	3,351.2	3,662.6	4,250.3
Total daily freeway VMT	4,716,400	10,751,400	11,479,700
Total daily surface-arterial VMT	12,967,400	19,839,900	18,835,100
Total daily local VMT	1,065,100	2,237,100	1,901,800
Daily average trip speed, mph	27.0	23.3	28.3
Peak-hour average trip speed, mph	22.8	16.8	23.4
Daily CO pollution, lb	2,020,574	818,110	767,219
Daily HC pollution, lb	334,114	98,806	93,871
Daily NO_x pollution, lb	233,960	106,884	106,402
Daily gasoline consumed, gal	1,702,601	2,950,939	2,893,815
Total annual fatalities	220	374	363
Total new construction cost, dollars	–	1,038,496,000	1,865,749,000
Jobs relocated	–	3,001	9,114
Residents relocated	–	12,380	17,660

Note: 1 mile = 1.6 km. 1 lb = 0.45 kg. 1 gal = 3.8 l.

Figure 5. Model ADT versus ground counts for Phoenix.

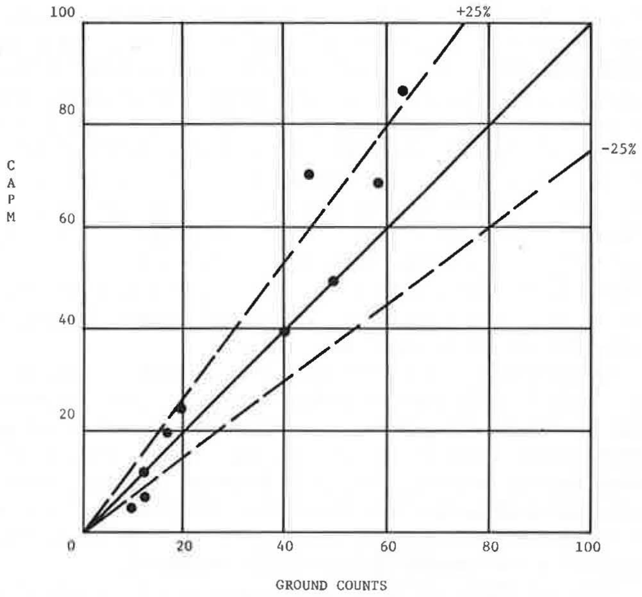
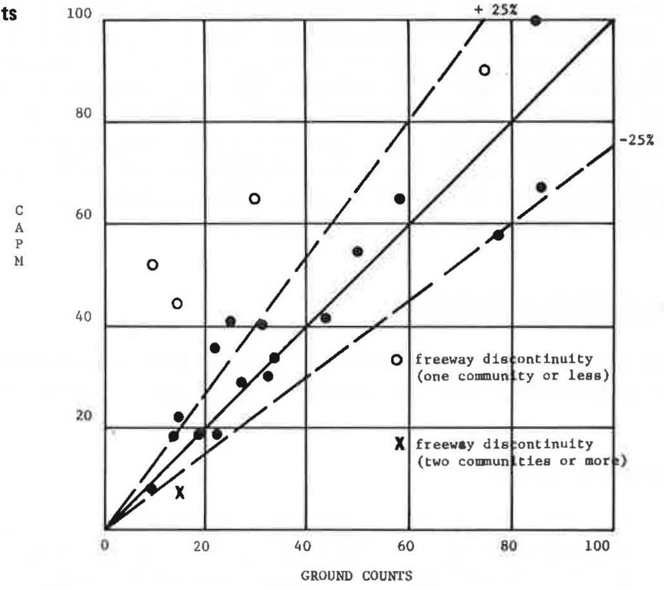


Figure 6. Model ADT versus ground counts for St. Louis.



more money is required to build roads, and a considerably greater number of jobs and people must be relocated. Although the above considerations are for the region as a whole, the same information is output for each community so that localized impacts may be examined.

Such simple comparisons make CAPM useful. The model does not make any decisions; these are reserved for the appropriate decision maker. What it does provide is reasonable and easy to understand information on which to base these decisions. Currently, only preliminary indications of the model's accuracy are available; however, data for base years have been analyzed in Phoenix and St. Louis. Phoenix has a very regular network layout, is basically contiguous, and showed excellent results. Data from ground counts and assignment indicated about 13 million regional VMT (21 million vehicle km), of which 1.25 million VMT (2 million vehicle km) were on freeways. CAPM, using the average work-trip time as reported and no adjustment (slight changes in average work-trip time), estimated less than 14 million regional VMT (22 million vehicle km), of which about 1.3 million VMT (2.1 million vehicle km) were on freeways. St. Louis, with the Mississippi River as a natural barrier, had a data base that did not exactly match the CAPM base system, but the results were quite pleasing. Regionally, CAPM showed 18.9 million VMT (30 million vehicle km) total, of which less than 4 million VMT (6.4 million vehicle km) were on freeways. Data indicated 19.7 million total VMT (32 million vehicle km) of which 3.7 million VMT (6 million vehicle km) were on freeways. Here, however, reported work-trip time was shifted (by about 5 percent) to bring the regional VMT into line.

Community-level VMT data are difficult to obtain. However, Figures 5 and 6 show how well CAPM replicated base-year volumes along segments of the freeways in Phoenix and St. Louis respectively. For Phoenix only 1 out of 10 points falls outside the 27 percent range. For St. Louis, the plot shows that, ignoring points where the freeway network has discontinuities, only 3 out of 17 points fall outside the 25 percent range. Considering that both cities were run with exactly the same model, calibration consisting of no more than inputting average work-trip time, the results are quite pleasing and suggest a reasonable theoretical foundation.

The CAPM process is an attempt to fill a critical void in transportation planning methodology, namely, the need for a first-cut tool to quickly sort through the many alternatives that must necessarily be examined for current planning. The key word is quickly; response to questions must come when they are asked, not 6 to 12 months later. The approach presented here is compact in that outputs appear in a simple and ready-to-use form, and there is no need to run multiple computer programs. Comparisons with field data indicate that the procedure is sufficiently accurate to deal with the broad policy questions that are of interest. One problem, however, is the back-door approach to transit, in which the transit analysis is done outside the program. Work is currently under way to remedy this by making the CAPM process multimodal and by including a set of transit outputs in the performance module. When this is accomplished, CAPM will be an even more useful tool.

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