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Transit Information System and Evaluation Capability to Support Subarea Transportation Planning and Implementation

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The key features of a multipurpose information system and detailed evaluation capability to support transit system planning in the Dallas-Fort Worth area are summarized. The system was specifically designed to enhance a sophisticated subarea travel demand and evaluation technology so as to allow short- and long-range multimodal planning efforts to be conducted. The system was developed jointly by the North Central Texas Council of Governments, local transit operators, and a consultant. Essential transportation planning data are available on both a transit link and line basis, including supply, utilization, environmental, and financial performance measures. The use of the information system is illustrated by a case study example.

In response to the increasing demands placed on the transportation planning process in recent years, the North Central Texas Council of Governments (NCTCOG) has been active in developing a technical planning capability to assist transportation decision making in the Dallas-Fort Worth area. This technical planning capability has three key components. They include regional sketch-planning analysis that adapts the Short-Range Generalized Policy model system (1,2), detailed travel forecasting analysis and evaluation by use of sophisticated subarea (subregional, corridor) focusing techniques (3,4), and individual transportation project evaluation that involves the use of a handbook of manual methods (5).

This paper describes a recent enhancement to NCTCOG subarea capabilities--namely, a multipurpose information system and detailed evaluation capability for transit. A parallel effort not described here is the development of the subarea travel demand forecasting capability for transit. This new transit capability in its entirety, along with the existing subarea planning technology, provides a powerful multimodal planning tool. This technology is responsive to short- and long-range planning needs, sensitive to transportation system management (TSM) actions, applicable to analysis of capital-intensive transit alternatives, beneficial for the evaluation of transportation control measures, and generally applicable to the transportation evaluation needs of local governments.

The principal focus of this paper is to describe the subarea transit information system and evaluation capability. This new system was designed with the aid of John Hamburg and Associates, Inc. (6), to be compatible with travel forecasting requirements, Urban Transportation Planning System (UTPS) programs including INET, and the NCTCOG Thoroughfare Information System (7). This paper describes the context of the information system in view of the total subarea capability, network coding and processing, and overall data-base management to satisfy both evaluation needs and requirements of the travel forecasting process, plus example performance measures and computer graphics support available for planning applications. The final section discusses the major conclusions and future directions for development.

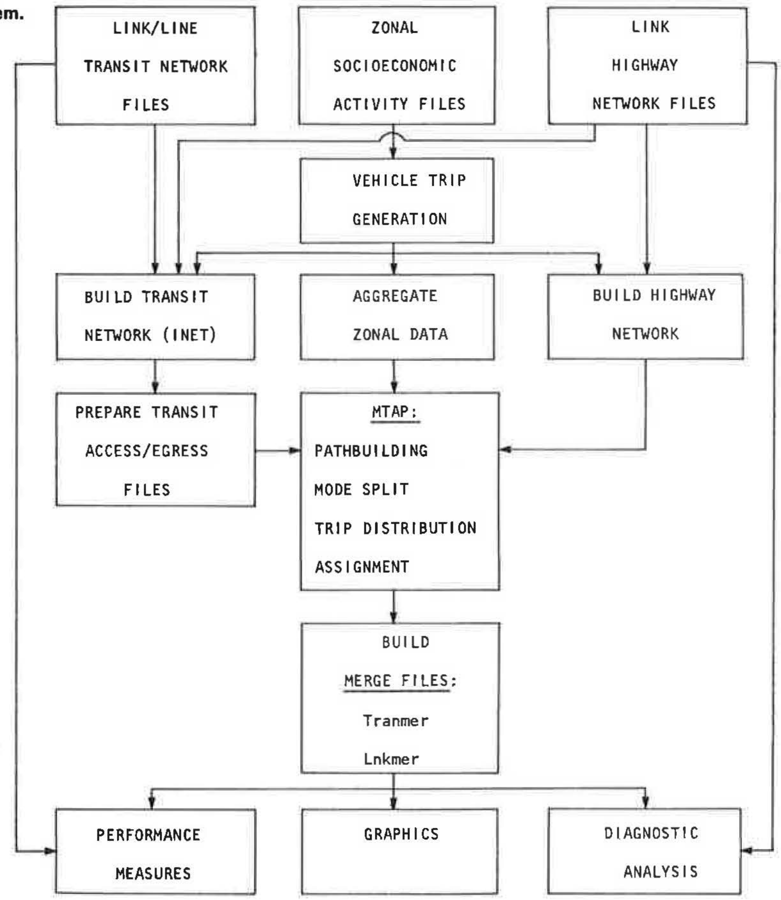
BACKGROUND

As mentioned previously, the transit information system operates within the context of a larger multimodal subarea analysis and evaluation system. An overview of that system is shown in Figure 1. Its principal features are outlined below:

1. Subarea focusing--Computerized procedures build network and zonal activity files that contain extensive detail for the subarea under investigation. Typically, these files include the finest detail in the area of interest and gradually less detail as distance from a subarea increases.
2. Structured data base--Subarea focusing is made possible by a rich hierarchical data base. At the finest level of detail, more than 12 000 highway links, 4000 transit links, and socioeconomic data for 7000 zones are available for a region that covers more than 2500 miles^2. For a particular application, automatic zone aggregation and network culling may result in 200-400 zones and 2000-4000 highway and transit links.
3. Evaluation capability--To facilitate the definition and evaluation of alternatives, analysis process outputs and network and zonal files are merged and input to computational procedures that provide an automatic accounting of performance measures. The measures describe network supply, utilization, operation, and impacts such as fuel consumption and air pollution emissions. Measures can be summarized in tables or displayed with network and zonal graphics.
4. Streamlined processing--The validated multimodal transportation analysis process (shown as MTAP in Figure 1) has been highly streamlined. Its execution is flexible, allowing either the submodules of the process to be run independently or the entire process to be run sequentially. If desired, the user can enter the process and alter parameters in response to special analysis needs.

Since the primary focus of this paper is the transit information and evaluation capability, the analysis process (MTAP) is shown in Figure 1 as a single

Figure 1. Overview of multimodal planning system.



box. The process is very complex and robust and will be the subject of future documentation.

The remainder of this paper details the information components. Pertinent network coding and processing steps are described. Evaluative capabilities are also illustrated in the context of a subarea application currently under way at NCTCOG.

NETWORK CODING

Transit network coding procedures implemented for the transit information system take full advantage of the fact that many transit routes traverse the existing highway network. Since the regional transportation planning data base already incorporates data elements that describe individual highway links (7), it was decided, as part of the design of the information system, to take advantage of this detail. The availability of the UTPS program INET reinforced that design decision.

There are two principal advantages of such an approach:

1. Maintenance of the highway data base coincidentally incorporates maintenance of the transit line data base.
2. Transit coding is simplified to coding line characteristics such as headway and time period of operations; line segmentation characteristics such as type of right-of-way, speed, and stop density factors; and the network node strings over which the particular route or line segment traverses.

With such a coding design, network verification requires that the physical routings of a particular system are adequately reflected in the coding and that coded operating characteristics are free of errors that would affect subsequent analysis. The transit information system allows for such verification. By plotting the coded network and comparing alignments with the design concept from which it was coded, it is possible to detect and correct invalid transit line routing. Further, data-base elements are checked for compatibility by using several update and edit software programs (prior to INET) so that invalid data items are prevented from becoming an integral part of the transit network. Additional ad hoc software provides written reports of network characteristics at various checkpoints within the entire coding procedure, which again maintains network viability.

NETWORK PROCESSING

The UTPS transit processing battery of programs, including INET, UPATH, UPSUM, and ULOAD, was incorporated as an integral submodule of the transit information system. The information system provides the software interface to the program INET through a sequence of locally developed software packages that make it possible to supply user-defined selection of transit characteristics (such as analysis year, time of day, headway, and travel speed) in a master transit data base. The processing flow can be generalized as follows:

1. Update and edit major transit line files, providing line and route characteristics associated with the transit network being developed. Ensure compatibility with the highway network where applicable.
2. Construct and edit the nontransit supportive

network, including the walk network and zonal connector links.

3. Select the time of day for analysis and construct time-of-day-specific transit line files.

4. Construct INET-compatible input files from time-of-day-specific files and nontransit supportive network files.

5. Build the transit network by using INET and extract summary network supply data for subsequent use.

6. Construct minimum-impedance transit skim trees by using the UTPS programs UPATH and UPSUM.

Once skims are available from the information system, MTAP trip-distribution and modal-choice estimates can be made and subsequently input to obtain transit network volumes. After assignment, the information system allows for the merging of assignment volumes and other transit network characteristics into transit line and link data-base components. This provides the necessary inputs for performance-measure summaries, diagnostic computation, and evaluation of alternatives.

DATA MANAGEMENT

The transit information system data base consists of five major or parent files, each of which has corresponding subfiles generated in response to specific analysis needs. The five major files include the major thoroughfare link (MTL) file, the major thoroughfare node (MTN) file, the major transit link (MTRL) file, socioeconomic activity files, and the major nonhighway transit link (MLNK) file.

The MTL file and its companion, the MTN file, provide the physical characteristics and spatial orientation of highway links within the region. The MTRL file contains multiple records that describe in detail transit line characteristics, including data items such as headway, mode, and line identification; segmentation characteristics such as vehicle free speed, stop delay time, and segment right-of-way type; transit route definition as indicated by node string delineation; and, optionally, scheduled time points along the defined route. The socioeconomic activity files describe zonal characteristics related to land use, population, employment, and the level of service for transit access and egress submodes. The MLNK file describes, in a manner similar to the MTL file, non-highway oriented transit and transit support network links.

Maintenance of each data-base element is an ongoing process. Within the context of the transit information system, the update and edit module provides the necessary software for a primary data-base management capability. In addition, the update and edit module is a tool used to modify the data base in response to multiple analytical requests without having to totally recode a network. In this way, the update and edit module allows several requests to be simultaneously processed without adverse effect on concurrent tasks.

A primary task of the transit information system is to convert the data-base elements into elements that are compatible with the UTPS transit software battery, particularly INET. Several programs, as an integral part of the system, allow this interface to occur while concurrently maintaining the integrity of the data base at a level of detail greater than that demanded by INET. The transit processing software maintains linkage with the focused subarea zonal structure within the UTPS interface module, which ensures compatibility with any automobile-only modal analysis that may be desired.

On completion of transit paths as processed by the UTPS program UPATH, control of data management is passed to that portion of MTAP starting with the modal-choice model. After this phase, control is returned to the main line of the transit information system. At this point, travel demand information--obtained from the modal-choice model, transit ridership assigned via the UTPS program ULOAD, and transit supply characteristics resulting from INET modeling of the network--is available within the system. The performance-evaluation interface module provides the software capability necessary to aggregate the travel demand, network supply, and impact information available within the data base. A post-assignment merge program, TRANMER, accesses both network supply and travel demand data, thus creating a single data base with pertinent evaluative information. This provides the basis for post-assignment impact and diagnostic software developed to act on transit line-based data. Similarly, transit link-based information and zonal activity data are posted in the data base via the program LNKMER. The detailed line- and link-based information assembly makes possible aggregation at various geographic levels. This allows impacts and diagnostics to be summarized solely within a particular area of interest, if desired, or for any substructure of the region.

EVALUATION FRAMEWORK

This section describes the rationale behind the evaluative capability contained in the transit information system. Because of the subarea nature of the system and, therefore, its potential application in a number of studies that have varying objectives, it was necessary to design a comprehensive but flexible approach that would respond to local decision-making criteria and produce results that could be easily interpreted. Essentially, the approach consists of the following:

1. Summarizing detailed performance measures for a baseline or base-year condition,
2. Diagnosing the condition to pinpoint problem areas and identify solution opportunities,
3. Defining alternatives based partly on the diagnostic results, and
4. Comparing the resultant performance measures across all alternatives.

The following discussion highlights the performance measures developed for this purpose, identifies the components of the diagnostic procedures, and demonstrates the approach in a case study application in the Dallas-Fort Worth area.

Performance Measures

The formulation of performance measures requires explicit consideration of the information necessary in diagnosing the transportation system as well as in evaluating the resulting alternatives. Table 1 lists performance measures, available from the transit information system, to meet these two requirements. These performance measures are divided into four groups: transportation supply and service, utilization and service productivity, environmental and safety impacts, and financial impacts.

In order to maximize the usefulness of these performance measures, several variables have a diagnostic quality whereas others have multiple uses. For example, vehicle hours delayed has a diagnostic quality when defined as the delay between transit speed and automobile speed. This approach to measuring delay is useful in that this value accounts for differences in in-vehicle time, a variable used in determining automobile and transit

Table 1. Transit performance measures.

Performance Measure	Link	Line	Performance Measure	Link	Line
Transportation supply and service			Average trip length		X
Vehicle miles	X	X	Environmental and safety impacts		
Vehicle hours	X	X	Energy consumption	X	
Vehicle hours delayed	X		Petroleum consumption	X	
Percentage of vehicle delay	X		Emissions		
Travel speed	X	X	Carbon dioxide	X	
Fixed-point headway	X		Hydrocarbons	X	
Average headway		X	Nitrogen oxide	X	
Required buses		X	Total	X	
Route miles	X		Bus-vehicle accidents	X	
Walk-access service area	X		Personal accidents	X	
Utilization and service productivity			Financial impact		
Passenger miles	X	X	Operating cost		X
Passenger hours	X	X	Revenue		X
Passenger hours delayed	X		Operating ratio		X
Total passengers		X			

Note: Numerous combinations of the measures given can be computed to summarize intensity (e.g., route miles per capita, passengers per vehicle mile, miles per gallon, and cost per passenger).

modal choice. High values of delay would therefore indicate those well-traversed locations where transit speeds are much lower than competing automobile speeds.

The required-buses variable exemplifies a multipurpose measure. This variable is defined as the estimated number of vehicles required to service a particular transit system. However, this value is used for several other purposes of particular interest to the transit operator. The number of bus vehicles, often dictated by the level of service in the morning peak network, determines the need for vehicle drivers. Variable costs due to the number of vehicles can also be estimated by using this measure. Increases in the demand for vehicles, due to different operating plans, must be explicitly addressed when conditions require long lead times for bus purchases.

Table 1 also gives the means by which the information on performance measures was obtained. Since transit performance can be described on a link or line basis, both approaches were adopted to calculate performance-measure values. Some variables, such as petroleum consumption, are best measured on a link basis that accounts for link-specific speed and volume variability. Link-based variables have the added ability to be aggregated into area summaries or districts for diagnostic use as well as into the subarea definition for a consistent comparison of alternatives.

A second means of calculating transit performance measures is on a line basis. Line-based measures represent important transit decision variables and add completeness to the information. Some line-based measures, such as average headway, can be measured only in this manner.

Aggregation of transit lines into line groups aids in reporting simplicity and normalizes transit loadings. Some variables, such as vehicle miles, are calculated by using both methods--for validation purposes as well as for developing intensity measures. All link and transit line measures are for an average weekday and include the service in the morning peak, midday, and evening peak periods.

Due to the large amounts of data generated by the performance measures and the frequent need to cross tabulate this information (e.g., average speed, by mode and by zone), a graphic display of the information is presented by using three-dimensional bar charts (8). Figure 2 shows an example application of this capability. Notice that eight of the blocks represents the magnitude of the measure. The use of this tool allows for both absolute reporting and relative comparisons and therefore allows a greater insight into the performance of the system in question.

The previously defined methodology contains an extensive list of performance measures. Certain site-specific measures are also necessary for responsive decision making. Examples of site-specific measures that are not currently included in this procedure are (a) impacts on historical buildings and sites, (b) impacts on recreational areas, (c) displacement of businesses and residents, (d) noise impacts at sensitive locations, and (e) disruption effects during construction.

Diagnostic Processes

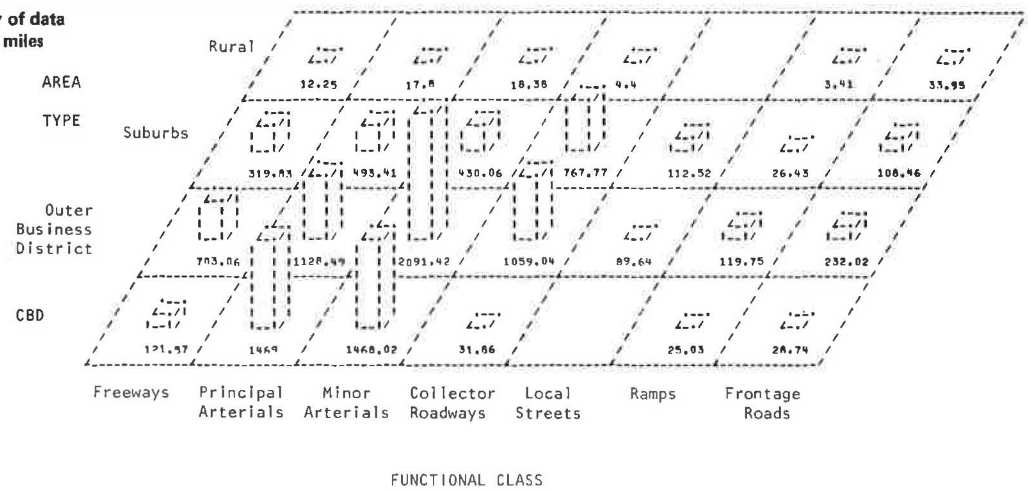
The reason for establishing diagnostic procedures is to apply the information provided by the performance measures in order to formulate potential transportation alternatives and packages. Two fundamental approaches have been adopted to address transit diagnostics. These procedures include the use of transit warrants and policy-generated standards to examine the existing transit system as well as the study of existing trip-oriented travel demand on a zonal interchange basis in order to examine appropriate levels of transit service. Both procedures have the ability to identify problem areas as well as locations for new service opportunities.

The examination of the existing transit system begins with the link, the transit line, and spatial aggregations of performance measures. These values are then compared with a wide variety of transit warrants, standards, and local transit policies [e.g., signal preemption becomes possible at non-central-business-district (non-CBD) locations with more than 100 vehicles/day] (9,10). Those link, transit line, and spatial aggregation performance measures that meet a particular warrant, standard, or policy are then flagged and mapped for closer examination. This procedure can determine a wide range of potential actions: for example, preferential treatment lanes, signal preemption locations, areas with low ridership, inadequate bus frequency, and the need for greater capacity modes.

By computer plotting the transit network along with key link-specific performance measures (e.g., daily buses, average headway, average speed, and average load factor), additional diagnostic value is gained through the visual presentation of key network information on CALCOMP model 563 plots. Such a capability makes it possible to highlight low-speed areas and hypothesize the rerouting of proximate transit lines in order to fulfill a preferential treatment warrant. A second diagnostic process has been developed to investigate appropriate transit levels of service by analyzing existing automobile travel on an interchange basis.

This approach examines travel demand on a zone-

Figure 2. Graphic display of data on subarea transit vehicle miles of travel.



to-zone basis. The analysis of highway and transit trip tables is intended to reveal potential service opportunities by defining locations where automobile use is substantial and transit service is insufficient. Poorly served transit areas (e.g., lack of crosstown routes and poorly connected or insufficient service) can be identified by using this approach. The results of this activity were not completed at the time this paper was written.

The adoption of the previously defined performance measures and diagnostic procedures aids in the detailed examination of the system in question. This approach, along with field surveys, citizen involvement, analysis of previous plans, the technical assistance of local government, and the input of elected officials, comprises a multifaceted information base for the generation and examination of alternative solutions.

CASE STUDY APPLICATION

The first application of the transit information system provides evaluation support for a multimodal subarea study in one of the most heavily traveled corridors in the Dallas-Fort Worth area. This subarea contains the north central portion of the city of Dallas and two of its northernmost suburbs. Local decision makers have given this subarea their highest priority for major new investment in both highway and transit facilities.

The subarea is approximately 140 miles^2 in area and contains a comprehensive mix of land uses including the Dallas CBD. Projections for this area indicate that by 1990 population will increase 35 percent above 1977 levels and employment will increase 55 percent. In order that a plan for providing adequate transportation services can be developed, the subarea study is examining transportation alternatives that are low capital and capital intensive for the short and long range.

The role of the transit information system in this case study is to facilitate the processing of networks used in base-year analysis (1977) and baseline analysis (1990 and 2000), to assist in the examination of network performance and the definition of alternatives, and to facilitate the evaluation of alternatives. For sake of illustration, the balance of the discussion in this paper is limited to the presentation of 1977 results.

A first and necessary step in applying a new evaluation methodology involves the validation of network performance measures by using observed information. Since the transit system under study contains bus routes that permeate the subarea boundary, the validation of the information system results is performed for the entire service region.

This validation includes a comparison of the linkand line-generated data from the information system, a comparison of this information with the INET modeled results, and a comparison of the output of all three methods with the information supplied by the local transit company. A small underestimation (14 percent) of the observed service is apparent and is most likely the result of not considering early morning (i.e., pre-morning-peak) and night service in the modeling process. The overestimation (10 percent) of peak buses can be attributed to the methodology inherent in the INET software. Discrepancies (1-3 percent) in the link and line information system are due to the distinct methodologies used in generating the data. In any event, the results are certainly within an acceptable tolerance.

Table 2 gives selected 1977 performance measures obtained from the link information system. Aggregation of this information into subarea districts reveals varying levels of service and impacts throughout the service region. Specific examples that demonstrate the use of this information are as follows:

1. Walk-access service area is defined as (100 * 0.5 * route miles per square mile). This value is 605 percent in the Dallas CBD and substantially less in less developed portions of the subarea.
2. Percentage of vehicle delay of transit, or that portion of bus performance spent in passenger-related boarding and alighting activities, is 41 percent in the subarea and 27.6 percent outside the subarea.
3. Transit travel speed varies between 7.2 miles/h in the CBD and 18.5 miles/h in outlying areas. The average transit speed is 11.7 miles/h in the subarea and 17.1 miles/h outside the subarea.
4. Hydrocarbon emissions vary between 6.6 grams/vehicle mile in the CBD and 4.1 grams/vehicle mile in areas that demonstrate higher average speeds.

The results of comparing link-specific performance measures with transit warrants and standards show 129 links within the subarea that exhibit low speeds and therefore are candidate locations for TSM actions. A large number of these locations are within the CBD and adjacent areas. More than 100 signal preemption locations were also determined, many within the CBD and on radial roadways within the subarea. Some CBD locations exhibit both low speed

Table 2. Selected subarea link-generated transit performance.

Performance Measure	Value of Measure by Aggregation District 1	2	3	4	5	6	7	Subarea Total
Vehicle miles	3 502.4	1 050.5	6 120.9	1 442.6	382.4	2.3	-	12 501.1
Vehicle hours	488.3	70.1	408.1	78.0	23.1	0.2	-	1 067.8
Vehicle hours delayed	272.5	14.8	123.5	20.3	6.3	0.0	-	437.5
Percentage of vehicle delay	55.8	21.1	30.3	26.0	27.5	27.8	-	41.0
Travel speed (miles/h)	7.2	15.0	15.0	18.5	16.6	13.1	-	11.7
Fixed-point headway (min)	7.3	19.8	14.1	29.3	38.6	188.6	-	15.2
Passenger miles	43 754.0	15 652.0	105 092.0	24 968.0	7 360.0	0.0	-	196 825.0
Passenger hours	5 903.0	976.0	7 131.0	1 389.0	441.0	0.0	-	15 853.0
Passenger hours delayed	3 193.0	196.0	2 167.0	354.0	121.0	0.0	-	6 032.0
Passengers per vehicle	12.5	14.9	17.2	17.3	19.2	0.0	-	15.7
Hydrocarbon emissions per vehicle mile	6.6	4.7	4.6	4.1	4.5	5.0	-	5.1
Route miles per square mile	12.1	2.7	3.5	1.0	0.8	0.0	-	1.0
Miles per gallon	3.1	4.8	4.7	5.1	5.1	4.7	-	4.1
Walk-access service area (%)	605.0	135.0	175.0	50.0	40.0	0.0	-	50.0

values and warranted signal preemption locations.

A second preferential treatment strategy was examined that included such actions as preferential curb lanes, contraflow lanes, and median bus lanes. In all, 24 locations were identified, including a 1.5-mile curb lane in the CBD.

As the study progresses, similar analysis will be necessary for the 1990 and 2000 baselines. Implementation of previously outlined diagnostic approaches will aid in the formulation of capital alternatives. Once determined, these TSM packages and alternatives will be examined with the aid of this evaluation process. Reporting on such categories as transportation supply and service, utilization and service productivity, environmental and safety impacts, and financial impacts will aid in the selection of an appropriate alternative.

CONCLUSIONS AND FUTURE WORK

This paper has described a major enhancement to existing subarea planning capabilities at NCTCOG. This enhancement allows transit networks to be coded, transit performance to be computed, and transit alternatives to be both defined and evaluated in a multimodal context.

The transit network coding process is simplified by taking full advantage of an existing highway network where possible. Network editing is performed early, prior to full-scale network building, to minimize computer costs. The network building process is flexible, allowing users to alter much of a network design configuration without having to manually recode the entire network.

Data management of the transit information system provides for interaction between network files and travel demand software, thus allowing performance measures to be computed. Because of the link and line detail available, performance measures have enhanced sensitivity and can be aggregated in order to examine and compare performance for portions of a subarea as well as to compare subarea alternatives. Graphic displays provide convenient summaries of information, relieving users of sifting through lengthy computer printouts.

The transit information system was specifically designed to provide interactions with highway-based information as well. As a result, base-year and baseline conditions can be diagnosed so as to take advantage of both highway and transit system characteristics simultaneously. This allows the increasingly comprehensive definition and evaluation of TSM and capital alternatives.

As applications with this information system and evaluation capability increase over time, changes in coding, processing, performance, and evaluation are expected to occur. Five areas of future work are as follows:

1. Preparing additional software to eliminate certain labor-intensive coding tasks,
2. Providing more interactive network processing for even greater productivity,
3. Reviewing and monitoring performance-measure parameters so that impacts reflect appropriate sensitivity,
4. Broadening alternative evaluation procedures to include an internal cost-discounting procedure to estimate implementation and operational expenditures over the useful life of alternatives under consideration, and
5. Refining diagnostic standards and warrants by using values of performance measures obtained from locally selected alternatives.

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Data and Methodological Problems in Establishing State Gasoline Conservation Targets

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The Emergency Energy Conservation Act of 1979 gives the President the authority to set gasoline conservation targets for states in the event of a supply shortage. Data and methodological issues associated with setting state gasoline conservation targets are examined. The target-setting method currently used is considered and found to have some flaws. Ways of correcting these deficiencies through the use of Box-Jenkins time-series analysis are investigated. A successful estimation of Box-Jenkins models for all states included the estimation of the magnitude of the supply shortages of 1979 in each state and a preliminary estimation of state short-run price elasticities, which were found to vary about a median value of -0.16. The time-series models identified were very simple in structure and lent support to the simple consumption growth model assumed by the current target method. It is concluded that the flaws in the current method can be remedied either by replacing the current procedures with time-series models or by using the models in conjunction with minor modifications of the current method.

The Emergency Energy Conservation Act of 1979 (EECA) provides the executive branch of the federal government with two mechanisms for managing the impacts of a petroleum supply emergency. Title I of the Act provides authority for rationing gasoline but can be invoked only when a severe interruption of at least 20 percent exists or is judged likely to exist in the supply of gasoline, diesel fuel, and no. 2 heating oil for 30 days. For less extreme emergencies (the shortages of 1979 and 1973-1974 would not have satisfied this criterion), Title II of the Act gives the President the authority to establish gasoline conservation targets for states. As the country's only plan for coping with supply interruptions short of disastrous proportions, the target-setting provisions of EECA assume considerable importance.

Since the passage of the act late in 1979, target-setting procedures have been developed for motor-vehicle gasoline only. This paper reviews the data requirements of the motor-vehicle gasoline target system and describes the method now established for setting targets, analyzes flaws and uncertainties in the existing method, and describes an investigation of the use of autoregressive, integrated moving average (ARIMA) time-series statistical models as a substitute method for forecasting state base-period consumption. Finally, conclusion are presented.

CURRENT METHOD AND ITS DATA REQUIREMENTS

Title II of the EECA grants the President authority to set state and national conservation goals for motor fuels when he deems them necessary because of an energy supply shortfall. The EECA House-Senate Conference Report (1, p. 11) states, "The state conservation target for any energy source shall be equal to the state base period consumption reduced by a uniform national percentage." This state base-period consumption is defined by the report as the product of consumption "during the corresponding month in the 12-month period prior to the first month for which the target is established" and a growth adjustment factor "determined on the basis of trends in the use in that state of such energy source during the 36-month period prior to the first month for which the target is established." Recognizing that inequities could arise in a strict application of this method, the act gives the President authority to adjust a state's base-period consumption estimates to compensate for (a) reductions in consumption already achieved by conservation, (b) previous energy supply shortages, and (c) variations in weather from seasonal norms. It is not stated how this is to be done.

From these provisions and the purpose of the act, it is clear that data on motor fuel consumption are required that (a) are an accurate reflection of consumption, (b) are available for all states, (c) are monthly, (d) are part of a continuous time series of at least 36 months, and (e) are continually and promptly reported. Only two public data series on motor-vehicle gasoline use were found that approached these requirements: (a) Table MF-33G motor gasoline use data compiled by the Federal Highway Administration (FHWA) from data reported by states based on state tax receipts and (b) Form EIA-25, "Prime Suppliers Monthly Report," a U.S. Department of Energy form filled out primarily by producers, importers, and interstate bulk terminal operators.

An analysis of these two data sets (2) indicated that the FHWA data were preferable for establishing gasoline conservation targets for two reasons:

1. The FHWA data reflect the quantity of motor gasoline sold for taxable (and certain nontaxable) distribution (i.e., retail sale) within the state during the month. On the other hand, the Form EIA-25 data are reported to the state by the major suppliers, who are typically one more step removed from final consumption.
2. Whereas both series are known to contain reporting inaccuracies, those of Table MF-33G were, in theory, correctable. With the Table MF-33G data it was at least feasible to reconstruct an accurate time series because, although many states allowed reporting lags or were lax in their own reporting procedures, the original tax records still contained the actual date on which tax liability was incurred. Because of this there was the possibility of going back through the tax records and sorting out the actual pattern of consumption.

During the analysis of the Table MF-33G data,