Urban Transportation Planning System: Philosophy and Function

Robert B. Dial, Office of Transit Planning, Urban Mass Transportation Administration

This paper describes the philosophy and functional requirements of a computer-based system for urban transportation planning. It begins with a view of the current transportation problem and the resulting demands on the planner. After outlining a planning framework composed of three analytical activities—long-range planning, short-range planning, and system surveillance—the paper describes the functions of a software system that would effectively support today's transportation planner. Such a system is currently under development at the Urban Mass Transportation Administration.

In the 1950s, transportation planners dealt in unimodal terms, undisturbed by social and environmental nightmares and unaware of energy crises.

In the 1970s, some planners began to perceive the apparent ineptitude of their perspective. During those 20 years, Americans invested trillions of dollars in automobiles, roads, parking facilities, traffic signals, police officers, traffic courts, hospitals, insurance companies, tire factories, oil industries, drive-ins, and billboards—all in deference to the private automobile-highway system. Yet, in spite of this enormous capital expenditure, congestion still paralyzes the cities, which smell awful and look worse than they did 20 years ago.

In their own defense, planners can argue that they should not be faulted for the current state of affairs. They had been misguided in their ignorance of the issues. Only those supporting the popular demand for more cars and more roads had urged them to consider costs and benefits. They had lacked both the technical and fiscal wherewithal to plan for, much less build for, anything but the automobile-dominated existence supported at enormous national expense.

It was not until the 1960s that federal legislators admitted that urban residents could not move by car alone and looked to transit for help. Like an aged football player abruptly recalled from retirement to substitute for the limping superstar, public transportation was dusted off, given an aspirin, and sent into the dying seconds of the game. Renamed mass transportation, it was expected to reduce congestion so that automobiles could go faster. Transit was given less than 1 percent of the capital budget spent on the automobile-highway system and was asked to solve the problems that the automobile had caused. And to make matters worse, transit operations were not federally subsidized.

Since the 1950s, planning procedures have changed little. The technical expertise needed to solve problems (problems unknown in the fifties) has increased by an order of magnitude. But new methods are needed to deal with the transportation issues of the seventies, such as priority lanes, congestion pricing, dial-a-ride, personal rapid transit, environmental impact statements, energy conservation, quality of life, and UMTA capital grant. The problems are new, and the ground rules for their solutions have changed. UMTA's current concerns and goals are described below.

LESSONS LEARNED

Examination of transportation planning during the last 20 years teaches four lessons that must be learned if transportation planning in the future is to be successful and if urban transportation systems are to be saved from inexorable decay.

The first lesson is that the transportation problem can be solved only at the local level. It is apparent that the problem was made worse by a federal tilt toward highways during the last 20 years, and federal policy that earmarks dollars for specific modes, regardless of local needs and desires, aggravates rather than ameliorates the situation. Any effective solution will likely require a better use of the automobile coupled with vastly improved public transportation.

The second lesson is that we must make better use of existing transportation resources and not automatically assume, in response to a problem, that what we need is more. Our superb highway system is 50 percent underused about 90 percent of the time. Too often roads are conceived of as providing for the movement of cars and trucks, not of people and goods, while in fact at certain times it is advantageous to ban cars and trucks

Publication of this paper sponsored by Committee on Transportation Systems Design.

from some segments of the road system. Public transit riders, pedestrians, and cyclists should receive much higher priority in the planner's mind and on the city's streets.

The third lesson is that urban transportation planning, implementation, and operation must be coordinated without an artificial administrative and jurisdictional partitioning of functions and responsibilities. Planners must guide builders. Operators must trust planners. Planners must be informed by builders and operators. In the past, these people scarcely knew one another. Today they must work together.

The fourth lesson is that planners must consider a much larger set of options and issues. They must look for more and better transportation alternatives. The evaluations of these alternatives will, in large measure, be based on nontransportation issues. Not only is today's problem more acute, but also the constraints on feasible solutions are tighter. More technical expertise is required.

Today, planners must plan a system, not merely design appendages to growing freeways. They now must justify their recommendations through lengthy analyses of alternatives and examination of vastly different and sometimes radical proposals. They must describe and defend the numerous potential impacts of a proposed plan to impatient politicians, a vociferous press, and a suspicious public, whose questions are selfish, diverse, and microscopic. A decision to build will never again be based on a simplistic travel time measure. Many other criteria, often conflicting, must be addressed.

NEEDED: IMPROVED PLANNING TOOLS

Despite the staggering problems of this new era of transportation planning, a clear view of the stunning differences between the fifties and the seventies can help us decide what kinds of tools are needed.

Traditional planning techniques now in common use are slow and costly: slow because they use a hunt-and-peck system to find a good plan and costly because of long turnaround times and high data costs. Their most serious weakness is the inability to evaluate multimodal planning alternatives accurately and responsively. At best, they plan effectively for one mode, the private automobile.

Local planners are keenly aware of these shortcomings. They must respond quickly to local policy questions. Despite inadequate resources, they must go ahead and plan with what they have. Piecemeal efforts of local planning agencies to improve tools often cost more than their marginal success is worth. The federal government's research and development of improved planning techniques will be especially valuable and welcome at the local level.

RESPONSES OF THE URBAN MASS TRANSPORTATION ADMINISTRATION

For as many years as large computers have been available, state and local agencies have used them to plan. UMTA research and development best helps local planners by packaging the best products in computer software. In this way UMTA provides technical and fiscal support necessary to improve local planning.

In 1972, the UMTA Office of Research and Development began a program to

1. Research and develop improved planning techniques,
2. Implement these techniques in generalized computer software,
3. Pilot test software in urban areas to ensure its appropriateness and demonstrate its utility,
4. Distribute the software to local planners, and
5. Provide technical backup by training users and responding to queries from the field.

The result of this program is the urban transportation planning system (UTPS). UTPS is a package of computer programs for site-specific planning of multimodal transportation systems. The package is evolutionary in that it is constantly enlarged and updated. Its ultimate goal is a streamlined, easy-to-use set of modular tools applicable to several planning activities.

UTPS PLANNING PHILOSOPHY

Two considerations affect the design of UTPS. First, variations in local issues and resources bring about many different planning situations, and no one model fits them all. Second, to be easy to use and yet adequately sophisticated, the technical complexity of UTPS must in large measure be invisible to the user, like that of a telephone.

To accommodate the variety of planning situations, UTPS distinguishes three overlapping, sequential, and iterative planning activities: long-range planning, short-range planning, and system surveillance (Figure 1). The first provides a context for the second; the second precedes implementation; and the third monitors performance to feed information back to the first two. Each is discussed below.

Long-Range Planning

There are two types of long-range planning. One searches for a strategy, and the other articulates in some detail a design within a selected strategy. We call these strategic (or sketch) planning and tactical planning (Figure 2). Both involve both manual and computerized processes. When computerized, each entails the design, coding (for computer consumption), evaluation, debugging, and improvement of a transportation system concept (Figure 3).

Sketch planning in long-range planning is the preliminary screening of possible multimodal configurations or concepts under varying assumptions regarding alternative futures. It is an aggregate, multivariate system evaluator and comparer. Especially needed in long-range regional planning (10 to 20 years), sketch planning, at minimum data costs, yields preliminary estimates of capital and operating costs, patronage, wide corridor traffic flows (by mode), service levels, and land development implications for a multimodal network. It also estimates factors such as energy consumption and air pollution. It compares all these data with those available for other networks and provides the information needed for broad policy decisions.

The demands on such a strategic model for long-range planning are challenging. First it must be very easy and quick to evaluate credibly an alternative strategy. Future options are limitless. Scores of them must be considered, and thus each must be done quickly. Second, the model must have capabilities for simulating the performance of modes that are as yet unspecified. Third, it must deal explicitly with uncertainty. Two of the most annoying uncertainties are those associated with socioeconomic and land developments and those associated with the costs and performance of new transportation technologies.

Sketch planning input is characterized by a small (less than 800 nodes) but rich abstraction of a multimodal network. By using highly aggregated measures, it compares a large number of proposed policies in analytical detail just sufficient to support strategic decisions. Trip generation, distribution, modal split, and assignment—traditionally four different technical steps—are handled in a single step. Supply-demand equilibriums are explicitly considered. Outputs relate directly to the issues. It evaluates a single system alternative at less than 10 percent of the cost of existing long-range planning techniques.

The planner remains in the sketch planning mode until possible comparisons are made or a strategic plan worthy of consideration at the tactical level is found.

Tactical planning treats the kind of detail appropriate to midrange (5 to 10 years) planning and identifies the best configuration within a given strategic concept uncovered in the sketch planning phase. The input and analytical techniques are close to those of today's state-of-the-art regional and corridor planning studies. Input includes the location of principal highway facilities and delineated transit routes. These feed a network model that addresses any automobile-transit vehicle interaction. Disaggregate demand forecasting techniques are applicable here.

In contrast to sketch planning, tactical planning can provide disaggregated cost and benefit measures that relate more accurately to the citizens and resources affected. At this level of analysis the outputs are estimates of transit fleet size and operating requirements for specific service areas, refined cost and patronage forecasts, level-of-service measures for specific geographical areas, and where necessary a program for staged implementation. Household displacements, noise, localized pollution, and aesthetic factors can also be evaluated.

The cost of examining an alternative in midrange planning is 10 to 20 times its cost in sketch planning, although default models, which assume away certain data requirements, might be run for a relatively inexpensive first look. Apparently promising plans can be analyzed in further detail, and problems uncovered at this stage may suggest a return to sketch planning to accommodate new restraints.

Short-Range Planning

As in long-range planning, there are two distinct types of activities in short-range planning. One is a quick evaluation of broad, areawide transportation strategies, and the other is detailed delineation of an optimal system design reflecting a given strategy. In the former, the difference between long and short-range strategic planning is that the short-range case requires more accurate cost-benefit estimates. Fortunately, greatly improved accuracy is obtainable. Also, the feasible transportation options in the short term are very limited, and the costs and capabilities of individual system components are accurately known. Additionally, in the short term, human behavior and demand for transportation are less difficult to forecast. Thus, a much more precise evaluation is possible. Some examples of the kinds of policies a short-range strategic model can address are

1. Areawide dial-a-ride service;
2. Widespread designation of automobile-free zones;
3. Road user tax or increased gas tax;
4. Order of magnitude increase in transit fleet size or exclusive guideway (lanes); and
5. Broad changes in parking policy.

Detailed delineation of the plan and the system's expected costs and benefits is required before the final decision is made to implement. The outputs of long-range tactical planning models and short-range strategic models are usually too abstract for engineering design purposes, but as the time to implement projects draws near (5 days to 5 years) detailed simulations can be made to refine design parameters. Some examples of activities at this stage are

1. Detailed evaluation of the extension, rescheduling, or repricing of existing bus service;
2. Simulation of bus priority lanes or signal systems;
3. Analysis of passenger and vehicle flows through a transportation terminal or activity center; and
4. Comparison of possible routing and shuttling strategies for a demand-activated system.

Analysis at this detailed level can be prohibitively expensive except for subsystems whose implementation is very likely and for cases in which such design refinements bring substantial increases in service or significant reductions in cost or uncertainty. Analysis at this level is effective only when the large number of exogenous variables can be accurately observed or estimated.

Surveillance

Besides enabling continual scrutiny and evaluation of transportation services, performance, costs, and use, the data from a good surveillance program support near-term planning to eliminate problems such as overloaded links, inadequate transportation opportunity, and the underutilization of existing resources. Knowledge of the current state of affairs is a prerequisite to any planning. It is essential that existing highway and transit systems and their users and environment be monitored to determine the service provided, to whom, and at what cost. Such data are needed for supply and demand model verification and calibration as well as for system evaluation. In addition to the traditional traffic counting, user-oriented surveys of things such as convenience and travel time must also be maintained. Information on citizens' travel patterns and socioeconomic attributes is also needed.

The development of good short-range planning and surveillance tools brings the greatest return for the model development dollar. This is especially true because the strong tradition of pure highway planning, preoccupied with long-range, capital-intensive programs, is of little help in the evaluation of immediate-action programs. Short-range planning provides the tools and analytical techniques badly needed to evaluate and optimize the use of a city's existing transportation resources. The development of these tools has high priority at UMTA.

UTPS FUNCTIONAL CHARACTERISTICS

To support the planner in the four stages identified above, UTPS acts as a highly interactive system, using time-shared computers with on-line graphics terminals, which is vastly different from the present slow-motion, error-prone batch operation. Interactive browsing through network and land use data, both digital and graphic, speeds up the planner's evaluations. Maps, charts, and graphs replace the millions of numbers that now overwhelm the planner (Figure 4). Graphic input via an electronic tablet speeds the data entry and run setup. An interactive network design model allows the planner to specify or to modify a plan virtually instantaneously. Many analytical processes are run while the planner waits at the cathode ray tube (CRT), giving him or her instant turnaround. Successful execution of the system is ensured by performing an interactive dry run of longer analyses that require batch processing. Later the planner interactively browses through the outputs of the batch process.

The UTPS program library includes data management routines, graphics routines, and algorithms for statistical and mathematical programming packages, and specific planning models, the software need to examine transportation supply and demand at each of the three planning levels described. UTPS modules meet uniform software design standards, and adherence to those standards allows UTPS to add new software and provide improved analytical techniques as they become available.

Among the most important modules are those for system evaluation, demand estimation, network aggregation, data acquisition, and data management.

System Evaluation

The system evaluation tool is an open-ended set of analytical reports and graphics, selected for the use of local planners, who may also add their own processes and reports on local issues. UMTA adds new reports as national issues arise. Local planners can compare significantly different network conceptions and make detailed analyses of the minor perturbations of a given network. They can evaluate present and proposed systems according to current and future demands. The other modules described below directly support system evaluation.

Demand Estimation

Planners making demand estimates may choose from three kinds of models: off-the-shelf default models for local use without site-specific parameter estimates, default models with locally calibrated parameters, and user-made models that can be integrated with an existing module with little programming effort.

Algorithms for establishing supply-demand equilibriums provide the capacity to determine route and mode selection equilibrium, origin-destination demand equilibrium, and land development-transportation equilibrium. The software supports the development, calibration, and application of both aggregate and disaggregate models.

Figure 1. The planning process.

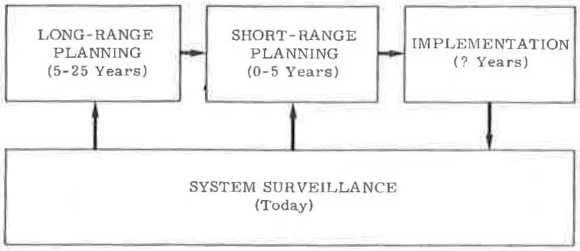


Figure 2. Planning types.

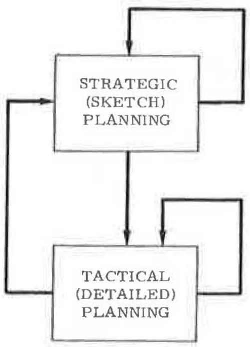


Figure 3. Computer-aided design.

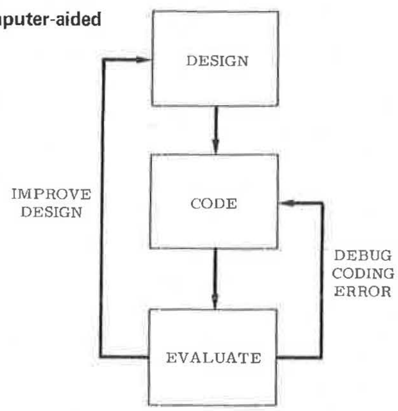
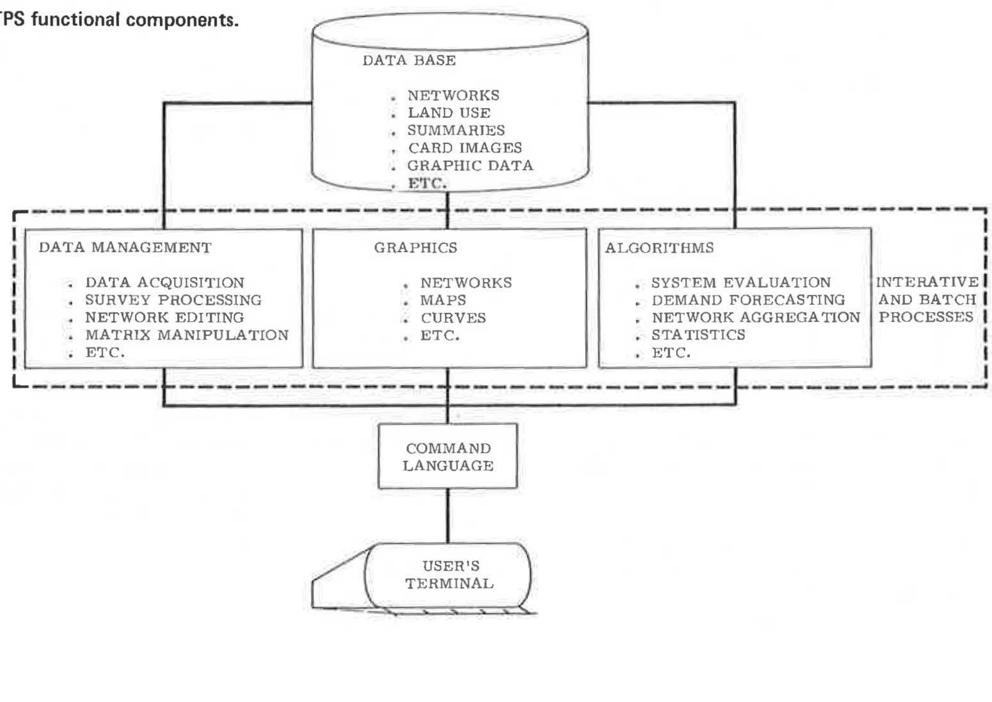


Figure 4. UTPS functional components.



Network Aggregation Models

Among the improved tools under research are the network aggregation models, which are useful at all levels of planning. The automatic reduction in size of the coded network description speeds up the computing process by providing the most efficient data base for an analysis. There are three network aggregation techniques: subarea windowing, regionwide abstraction, and subarea focusing.

Subarea windowing is the most straightforward technique. The software physically extracts a subarea of the network and collapses external demand to within the subarea's periphery. It can be used for detailed analysis and short-range planning when external demands are assumed to be fixed.

Regionwide abstraction is technically more difficult. The computer reduces detailed networks to a specified level of abstraction by aggregating links, nodes, and zonal data to yield a network amenable to sketch planning. This permits movement from the short-range stage back to the sketch planning stage and thus allows rapid macroscopic evaluations of detailed networks.

Subarea focusing is the most difficult technique because it combines windowing and abstraction. A subarea of interest is windowed; the links outside the window are not deleted but are abstracted, so any modification of the subarea's internal network can have the appropriate effect on external demand. This is accomplished by increasing network abstraction as distance from the window increases. Subarea focusing greatly improves the effectiveness of traditional long-range (tactical) planning and reduces its cost and increases its accuracy.

Data Acquisition

Although data collection is essential to planning in general and system surveillance in particular, the notoriously large sums of money spent on data acquisition should be channeled into more productive analyses. To do this, planners need more efficient data gathering techniques. UTPS must couple modern sampling techniques with the capabilities of an on-line, time-shared computer and modern data entry hardware to speed the collection, editing, and correcting of survey data and to reduce the cost. Also, a disaggregate travel demand data base is available to researchers to eliminate the need for more data in certain cases. Detailed network coding manuals show the planner the quickest way to input transportation system characteristics.

Data Management

The data management system is used to specify network and land use configurations, edit data, and evaluate systems. A good data management system must allow the planner to execute programs and interact with the data base without detailed knowledge of the data base's design. It should also be possible to provide a common source of data for all UTPS modules, allow efficient modification of the data base, avoid a proliferation of data files, and furnish a repository for output from computational modules.

Besides the many computational similarities (e.g., matrix manipulation), there are also many common data requirements among the three levels of planning analysis, such as network descriptions, land use data, and graphic data. Therefore, data preparation time and user training time are reduced, and the software is fully exploited. At any time the user can modify the basic network or land use data by using the interactive network design program. The modifications can be additions, deletions, or the updating of any or all elements; but the basic integrity of the original design and its predecessors is preserved in a tree-like file structure. At any time, the planner may analyze any version of the network. In UPTS a single data base might contain scores of networks, all quickly available for analysis.

The planner can design a network while graphically describing it to the computer. He or she sits at a CRT and, using a stylus or lightpen, draws the network, either by explicitly entering nodes, links, transit lines, and the like or by circumscribing parametrically geographical areas of homogeneous service (e.g., street spacing, number of bus stops).

The UTPS package can generate maps, charts, or graphs. When the software processes a request for graphics, it saves the results in the graphics file of the data base. The file contains the points, lines, and annotations that constitute the graphic in a standard format. The planner may browse through the available graphics at any time, recalling, combining, modifying, or displaying those needed, without the expense of regeneration. Attribute or land use data can be overlaid on network plots and the graphic directed to a display tube or hard-copy plotter.

CONCLUSION

All components and capabilities described above are among the objectives of the UTPS development. All are currently in a research or development stage. A few products have already been released to the planning community. Most are scheduled for future delivery.

In its present skeletal state, UTPS is 13 software modules and attendant documentation that form a fairly powerful suite of programs that run in the batch mode on the IBM 360/370 series of computers. Basically comprising a traditional transportation model, UTPS best supports long-range tactical planning but can provide limited service for the strategic or short-range planner. It includes highway and transit network analysis models, demand forecasting models, matrix manipulation, and limited graphics capabilities. It installs easily at the user's computer facility and is being continually improved as new developments arise.

It is hoped that, within 3 years, UTPS will evolve to include all the capabilities discussed above. It will be in a form that allows it to be fairly readily installed on non-IBM computers and will exploit mini-computer and nationwide computer network technologies. The result will be a ubiquitously available software system that will aid federal, state, and local planners who search for effective solutions to today's complex and vexing transportation problems.

ACKNOWLEDGMENTS

The design and development of UTPS are the product of individuals too numerous to list. Among the institutions they represent are Barton-Aschman Associates; Cambridge Systematics, Inc.; Comnet Corporation; Consad Research Corporation; Creighton, Hamburg, Associates, Inc.; De Leuw, Cather and Company; DTM Incorporated; First Data Corporation; Massachusetts Institute of Technology; Metropolitan Washington Council of Governments; National Bureau of Standards; Mitre Corporation; Peat, Marwick, Mitchell and Company; Planning Research Corporation; R. H. Pratt Associates; Wilbur Smith and Associates; Alan M. Voorhees and Associates; and the Urban Mass Transportation Administration, which provided financial support. Any federal policy that might be read into the paper is disclaimed.