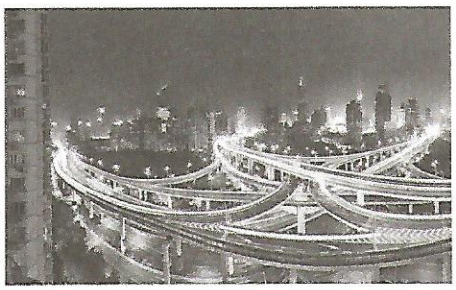
CHAPTER 11



The Transportation Planning Process

This chapter explains how decisions to build transportation facilities are made and highlights the major elements of the process. Transportation planning has become institutionalized; federal guidelines, regulations, and requirements for local planning are often driving forces behind existing planning methods.

The formation of the nation's transportation system has been evolutionary, not the result of a grand plan. The system now in place is the product of many individual decisions to select projects for construction or improvement, such as bridges, highways, tunnels, harbors, railway stations, and airport runways. These transportation projects were selected because a conclusion was reached that these projects would result in overall improvements to the system.

Among the factors that may justify a transportation project are improvements in traffic flow and safety, energy consumption, travel time, economic growth, air quality, and accessibility. Some transportation projects may have been selected for reasons unrelated to specific benefits; for example, to stimulate employment in a particular region, to compete with other cities or states for prestige, to attract industry, to respond to pressures from a political constituency, or to gain personal benefit from a particular route location or construction project. In some instances, transportation projects are not selected because of opposition from those who would be adversely affected. For example, a new highway may require the taking of community property, or the construction of an airport may introduce undesirable noise due to low-flying planes or take residential or wetland acreage to accommodate runway expansion. Whatever the reason for selecting or rejecting a transportation project, a specific process led to the conclusion to build or not to build.

The process for planning transportation systems should be a rational one that serves to furnish unbiased information about the effects that the proposed transportation project will have on the affected community and on users. For example, if noise or air pollution is a concern, the process will examine and estimate how much additional noise or air pollution will occur if the transportation facility is built. Usually, cost is a major factor, and so the process will include estimates of the construction, maintenance, and operating costs.

The process must be flexible enough to be applicable to any transportation project or system, because the kinds of problems that transportation engineers work on will vary over time. Transportation has undergone considerable change in emphasis over a 200-year period; such modes as canals, railroads, highways, air, and public transit have each been dominant at one time or another. Thus, the activities of transportation engineers have varied considerably during this period, depending on society's needs and concerns. Examples of changing societal concerns include energy conservation, traffic congestion, environmental impacts, safety, security, efficiency, productivity, land consumption, and community preservation.

The transportation planning process is not intended to furnish a decision or to give a single result that must be followed, although it can do so in relatively simple situations. Rather, the process is intended to provide the appropriate information to those who will be affected and those responsible for deciding whether the transportation project should go forward.

CHAPTER OBJECTIVES:

- Understand the major elements of the transportation planning process and how the process influences decision making.
- Explain the seven basic elements of the transportation planning process.
- Describe the five relevant processes for implementing transportation planning recommendations.
- Become familiar with the elements of urban transportation planning and travel forecasting.

11.1 BASIC ELEMENTS OF TRANSPORTATION PLANNING

The transportation planning process comprises seven basic elements, which are interrelated and not necessarily carried out sequentially. The information acquired in one phase of the process may be helpful in some earlier or later phase, so there is a continuity of effort that should eventually result in a decision. The elements in the process are:

- Situation definition
- Problem definition
- Search for solutions
- Analysis of performance
- Evaluation of alternatives
- Choice of project
- Specification and construction

These elements are described and illustrated in Figure 11.1, using a scenario involving the feasibility of constructing a new bridge.

11.1.1 Situation Definition

The first step in the planning process is *situation definition,* which involves all of the activities required to understand the situation that gave rise to the perceived need for a transportation improvement. In this phase, the basic factors that created the present situation are described, and the scope of the system to be studied is delineated. The present system is analyzed and its characteristics are described. Information about the surrounding area, its people, and their travel habits may be obtained. Previous reports

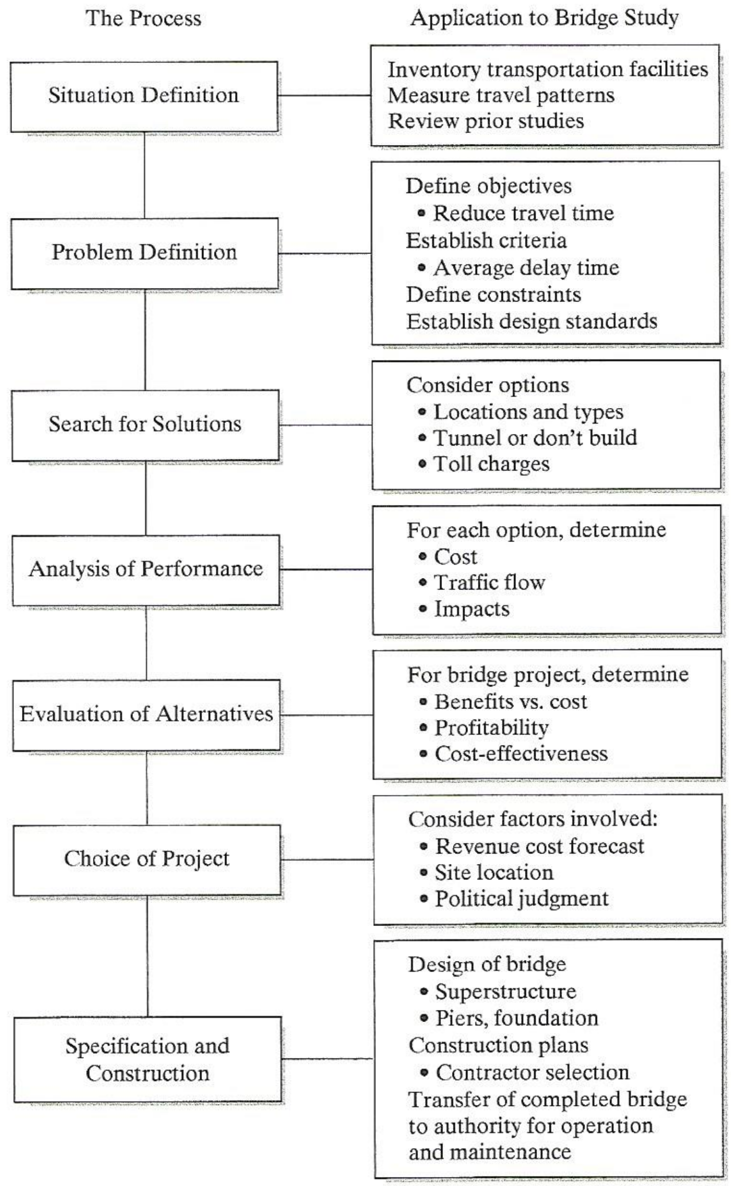


Figure 11.1 Basic Elements in the Transportation Planning Process Applied to Consider the Feasibility of a New Bridge

and studies that may be relevant to the present situation are reviewed and summarized. Both the scope of the study and the domain of the system to be investigated are delineated.

In the example described in Figure 11.1, a new bridge is being considered. Situation definition involves developing a description of the present highway and transportation services in the region; measuring present travel patterns and highway traffic volumes; reviewing prior studies, geological maps, and soil conditions; and delineating the scope of the study and the area affected. A public hearing is often held to obtain citizen input and in some instances, such as to comply with federal aid requirements, may be required.

The situation then will be described in a report that documents the overall situation and summarizes the results of the public hearing.

11.1.2 Problem Definition

The purpose of this step is to describe the problem in terms of the objectives to be accomplished by the project and to translate those objectives into criteria that can be quantified. Objectives are statements of purpose, such as to reduce traffic congestion; to improve safety; to maximize net highway-user benefits; and to reduce noise. Criteria are the measures of effectiveness that can be used to quantify the extent to which a proposed transportation project will achieve the stated objectives. For example, the objective "to reduce traffic congestion" might use "travel time" as the measure of effectiveness. The characteristics of an acceptable system should be identified, and specific limitations and requirements should be noted. Also, any pertinent standards and restrictions that the proposed transportation project must conform to should be understood.

Referring to Figure 11.1, an objective for the bridge project might be to reduce travel congestion on other roads or to reduce travel time between certain areas. The criterion used to measure how well these objectives are achieved is average delay or average travel time. Constraints placed on the project might be physical limitations, such as the presence of other structures, topography, or historic buildings. Design standards for bridge width, clearances, loadings, and capacity also should be noted.

11.1.3 Search for Solutions

In this phase of the planning process, consideration is given to a variety of ideas, designs, locations, and system configurations that might provide solutions to the problem. This is the brainstorming stage, in which many options may be proposed for later testing and evaluation. Alternatives can be proposed by any group or organization. In fact, the planning study may have been originated to determine the feasibility of a particular project or idea, such as adding bike lanes to reduce traffic volumes. The transportation engineer has a variety of options available in any particular situation, and any or all may be considered in this idea-generating phase. Among the options that might be used are different types of transportation technology or vehicles, various system or network arrangements, and different methods of operation. This phase also includes preliminary feasibility studies, which might narrow the range of choices to those that appear most promising. Some data gathering, field testing, and cost estimating may be necessary at this stage to determine the practicality and financial feasibility of the alternatives being proposed.

In the case of the bridge project, a variety of options may be considered, including different locations and bridge types. The study should also include the option of not building the bridge and might also consider what other alternatives are available, such as a tunnel or an alternate route. Operating policies should be considered, including various toll charges and methods of collection.

11.1.4 Analysis of Performance

The purpose of performance analysis is to estimate how each of the proposed alternatives would perform under present and future conditions. The criteria identified in the previous steps are calculated for each transportation option. Included in this step is a determination of the investment cost of building the transportation project, as well as annual costs for maintenance and operation. This element also involves the use of mathematical models for estimating travel demand. The number of persons or vehicles that will use the system is determined, and these results, expressed in vehicles or persons/hour, serve as the basis for project design. Other information about the use of the system (such as trip length, travel by time of day, and vehicle occupancy) is also determined and used in calculating user benefits for various criteria or measures of effectiveness. Environmental effects of the transportation project (such as noise and air pollution levels and acres of land required) are estimated. These nonuser impacts are calculated in situations where the transportation project could have significant impacts on the community or as required by law.

This task is sometimes referred to as the transportation planning process, but it is really a systems analysis process that integrates system supply on a network with travel demand forecasts to show equilibrium travel flows. The forecasting-model system and related network simulation are discussed in Chapter 12.

To analyze the performance of the new bridge project, preliminary cost estimates must be prepared for each location being considered. Then estimates of the traffic that would use the bridge are developed, given various toll levels and bridge widths. The average trip length and average travel time for bridge users are determined and compared with existing or no-build conditions. Other impacts (such as land required, visual effects, noise levels, and air or water quality changes) are also computed.

11.1.5 Evaluation of Alternatives

The purpose of the evaluation phase is to determine how well each alternative will achieve the objectives of the project as defined by the criteria. The performance data produced in the analysis phase are used to compute the benefits and costs that will result if the project is selected. In cases where the results cannot be reduced to a single monetary value, a weighted ranking for each alternative might be produced and compared with other proposed projects. For those effects that can be described in monetary terms, the benefit–cost ratio (described in Chapter 13) for each project is calculated to show the extent to which the project would be a sound investment. Other economic tests might also be applied, including the net present worth of benefits and costs.

In situations where there are many criteria, particularly in an environmental analysis, the results can be shown in a cost-effectiveness matrix (for example, project cost versus number of homes displaced) that will furnish a better understanding as to how each alternative performs for each of the criteria and at what cost. The results can be plotted to provide a visual comparison of each alternative and its performance.

In the evaluation of the bridge project, first determine the benefits and costs and compute the benefit–cost ratio. If the result is greater than one, the evaluation of alternative sites requires additional comparison of factors, both for engineering and economic feasibility and for environmental impact. A cost-effectiveness matrix that compares the cost of each alternative with its effectiveness in achieving certain goals will further assist in the evaluation.

11.1.6 Choice of Project

Project selection is made after considering all the factors involved. In a simple situation—for example, where the project has been authorized and is in the design phase—a single criterion (such as cost) might be used and the chosen project would be the one with the lowest cost. With a more complex project, however, many factors have to be considered, and selection is based on how the results are perceived by those involved in decision making. If the project involves the community, it may be necessary to hold additional public hearings. A bond issue or referendum may be required. It is possible that none of the alternatives will meet the criteria or standards, and additional investigations will be necessary. The transportation engineer, who participates in the planning process, may have developed a strong opinion as to which alternative to select. Such bias could result in the early elimination of promising alternatives or the presentation to decision makers of inferior projects. If the engineer is acting professionally and ethically, he or she will perform the task such that the appropriate information is provided to make an informed choice and that every feasible alternative has been considered.

Before deciding whether or not to build the proposed bridge, decision makers look carefully at the results of both revenue and cost estimates and consider projects that appear to be financially sound. The site location is selected based on a careful study of the factors involved. The information gathered in the earlier phases is used, together with engineering judgment and political considerations, to arrive at a final project selection.

11.1.7 Specification and Construction

Once the transportation project has been selected, the project moves into a detailed design phase in which each of the components of the facility is specified. For a transportation facility, this involves its physical location, geometric dimensions, and structural configuration. Design plans are produced that can be used by contractors to estimate the construction cost of building the project. When a construction firm is selected, these plans will be the basis on which the project will be built.

For the bridge project, once a decision to proceed has been made, a design is produced that includes the type of superstructure, piers and foundations, roadway widths and approach treatment, as well as appurtenances such as tollbooths, traffic signals, and lighting. These plans are made available to contractors, who submit bids for the construction of the bridge. If a bid does not exceed the amount of funds available and the contractor is deemed qualified to do the work, the project proceeds to the construction phase. Upon completion, the new bridge is turned over to the local transportation authority for operation and maintenance.

Example 11.1 Planning the Relocation of a Rural Road

To illustrate the transportation planning process, a situation that involves a rural road relocation project is described. Each of the activities that are part of the project is discussed in terms of the seven-step planning process previously described. This project includes both a traffic analysis and an environmental assessment and is typical of those conducted by transportation consultants or metropolitan transportation organizations. (This example is based on a study completed by the engineering firm Edwards and Kelsey.)

Step 1. Situation definition. The project is a proposed relocation or reconstruction of 3.3 miles of U.S. 1A located in the coastal town of Harrington, Maine. The town center, a focal point of the project, is located near the intersection of highways U.S. 1 and U.S. 1A on the banks of the Harrington River, an estuary of the Gulf of Maine. (See Figure 11.2.) The town of Harrington has 553 residents, of whom 420 live within the study

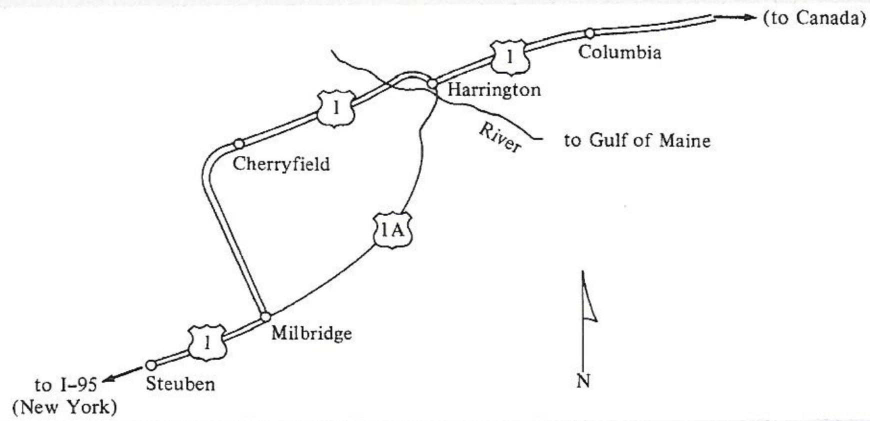


Figure 11.2 Location Map for Highways U.S. 1 and U.S. 1A

area and 350 live in the town center. The population has been declining in recent years; many young people have left because of the lack of employment opportunities. Most of the town's industry consists of agriculture or fishing, so a realignment of the road that damages the environment would also affect the town's livelihood. There are 10 business establishments within the study area; 20 percent of the town's retail sales are tourism related. The average daily traffic is 2620 vehicles/day, of which 69 percent represent through traffic and 31 percent represent local traffic.

Step 2. Problem definition. The Maine Department of Transportation wishes to improve U.S. 1A, primarily to reduce the high accident rate on this road in the vicinity of the town center. The problem is caused by a narrow bridge that carries the traffic on U.S. 1A into the town center, the poor horizontal and vertical alignment of the road within the town center, and a dangerous intersection where U.S. 1A and U.S. 1 meet. The accident rate on U.S. 1A in the vicinity of the town center is four times the statewide average. A secondary purpose of the proposed relocation is to improve the level of service for through traffic by increasing the average speed on the relocated highway.

The measures of effectiveness for the project will be the accident rate, travel time, and construction cost. Other aspects that will be considered are the effects that each alternative would have on a number of businesses and residences that would be displaced, the changes in noise levels and air quality, and the changes in natural ecology. The criteria that will be used to measure these effects will be the number of businesses and homes displaced, noise levels and air quality, and the acreage of salt marsh and trees affected.

Step 3. Search for solutions. The Department of Transportation has identified four alternative routes, as illustrated in Figure 11.3, in addition to the present route—Alternative 0—referred to as the null or "do-nothing" alternative. All routes begin at the same location—3 miles southwest of

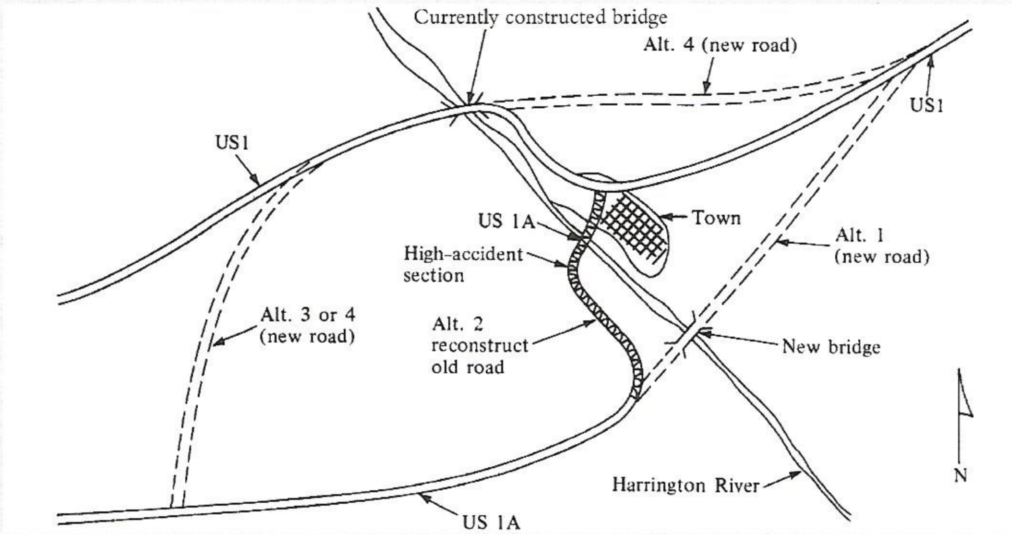


Figure 11.3 Alternative Routes for Highway Relocation

the center of Harrington—and end at a common point northeast of the town center. The alternatives are as follows:

- *Alternative 1:* This road bypasses the town to the south on a new location across the Harrington River. The road would have two lanes, each 12-ft wide with 8-ft shoulders. A new bridge would be constructed about one-half mi downstream from the old bridge.
- *Alternative 2:* This alternative would use the existing U.S. 1A into town, but with improvements to the horizontal and vertical alignment throughout its length and the construction of a new bridge. The geometric specifications would be the same as for Alternative 1.
- *Alternative 3:* This new road would merge with U.S. 1 west of Harrington, and then continue through town. It would use the Route 1 Bridge, which was recently constructed. Geometric specifications are the same as those for the other alternatives.
- *Alternative 4:* This road would merge with U.S. 1 and use the Route 1 Bridge, as in Alternative 3. However, it would bypass the town center on a new alignment.

Step 4. Analysis of performance. The measures of effectiveness are calculated for each alternative. The results of these calculations are shown in Table 11.1 for Alternatives 1 through 4 and for the null alternative. The relative ranking of each alternative is presented in Table 11.2. For example, the average speed on the existing road is 25 mi/h, whereas for Alternatives 1 and 4, the speed is 55 mi/h, and for Alternatives 2 and 3, the speed is 30 mi/h. Similarly, the accident factor, which is now four times the statewide average, would be reduced to 0.6 for Alternative 4 and 1.2 for Alternative 1. The project cost ranges from $1.18 million for Alternative 3 to $1.58 million for Alternative 2. Other items that are calculated include the number of

Table 11.1 Measures of Effectiveness for Rural Road

	Alternatives				
Criteria	*0*	*1*	*2*	*3*	*4*
Speed (mi/h)	25	55	30	30	55
Distance (mi)	3.7	3.2	3.8	3.8	3.7
Travel time (min)	8.9	3.5	7.6	7.6	4.0
Accident factor	4	1.2	3.5	2.5	0.6
(Relative to statewide average)					
Construction cost ($ million)	0	1.50	1.58	1.18	1.54
Residences displaced	0	0	7	3	0
City traffic					
Present	2620	1400	2620	2520	1250
Future (20 years)	4350	2325	4350	4180	2075
Air quality ($\mu g/m^3$ CO)	825	306	825	536	386
Noise (dBA)	73	70	73	73	70
Tax loss	None	Slight	High	Moderate	Slight
Trees removed (acres)	None	Slight	Slight	25	28
Runoff	None	Some	Some	Much	Much

residences displaced, the volume of traffic within the town both now and in the future, air quality, noise, lost taxes, and acreage of trees removed.

Step 5. **Evaluation of alternatives.** Each of the alternatives is compared with the others to assess the improvements that would occur based on a given criterion. In this example, we consider the following measures of effectiveness and their relationship to project cost.

Comparison of Each Criterion

- *Travel time:* Every alternative improves the travel time. As shown in Figure 11.4, the best is Alternative 1, followed by Alternative 4. Alternatives 2 and 3 are equal, but neither reduces travel time significantly.

Table 11.2 Ranking of Alternatives

	Alternatives				
Criterion/Alternative	*0*	*1*	*2*	*3*	*4*
Travel time	4	1	3	3	2
Accident factor	5	2	4	3	1
Cost	1	3	5	2	4
Residences displaced	1	1	3	2	1
Air quality	4	1	4	3	2
Noise	2	1	2	2	1
Tax loss	1	2	4	3	2
Trees removed	1	2	2	3	4
Runoff	1	2	2	3	3

Note: 1 = highest; 5 = lowest

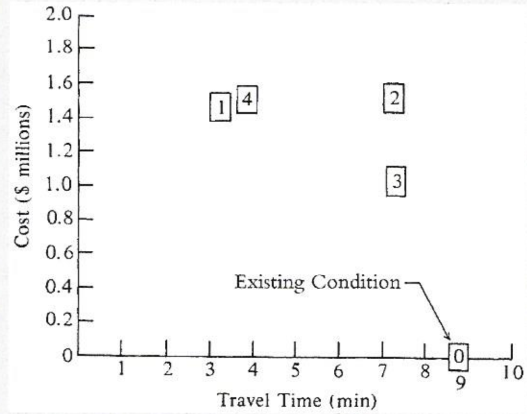


Figure 11.4 Travel Time between West Harrington and U.S. 1 versus Cost

- *Accident factor:* Figure 11.5 shows that the best accident record will occur with Alternative 4, followed by Alternatives 1, 3, and 2.
- *Cost:* The least costly alternative is simply to do nothing, but the dramatic potential improvements in travel time and safety would indicate that the proposed project should probably be undertaken. Alternative 3 is lowest in cost at \$1.18 million. Alternative 2 is highest in cost, would not be as safe as Alternative 3, and would produce the same travel time. Thus, Alternative 2 would be eliminated. Alternative 1 would cost \$0.32 million more than Alternative 3, but would reduce the accident factor by 1.3 and travel time by 4.1 minutes. Alternative 4 would cost \$0.04 million more than Alternative 1 and would increase travel time, but would decrease the accident factor. These cost-effectiveness values are shown in Figures 11.4 and 11.5. They indicate that Alternatives 1 and 4 are both more attractive than Alternatives 2 and 3 because the former would produce significant improvements in travel time and accident prevention.
- *Residences:* Three residences would be displaced if Alternative 3 were selected; seven residences would be displaced if Alternative 2 were selected. No residences would have to be removed if Alternatives 1 or 4 were selected.

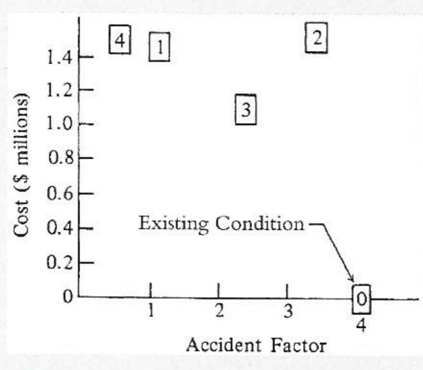


Figure 11.5 Accident Factor (relative to statewide average) versus Cost

- *Air quality:* Alternative 1 would produce the highest air quality, followed by Alternatives 4, 3, and 2. The air quality improvement would result from removing a significant amount of the slow-moving through traffic from the center of the city to a high-speed road where most of the pollution would be dispersed.
- *Noise:* Noise levels are lower for Alternatives 1 and 4.
- *Tax loss:* Tax losses would be slight for Alternatives 1 and 4, moderate for Alternative 3, and high for Alternative 2.
- *Trees removed:* Alternatives 3 and 4 would eliminate 25 and 28 acres of trees, respectively. Alternative 1 would result in slight losses; Alternative 2, no loss.
- *Runoff:* There would be no runoff for Alternative 0, some for Alternatives 1 and 2, and a considerable amount for Alternatives 3 and 4.

Step 6. Choice of project. From a cost point of view, the Department of Transportation would select Alternative 3, since it results in travel time and safety improvements at the lowest cost. However, if additional funds are available, then Alterative 1 or 4 would be considered. Since Alternative 1 is lower in cost than Alternative 4 and is equal or better than Alternative 3 for each criterion related to community impacts, this alternative would be the one most likely to be selected. In the selection process, each alternative would be reviewed. Also, comments would be received from citizens and elected officials to assist in the design process so that environmental and community effects would be minimized.

Step 7. Specifications and construction. The choice has been made, and Alternative 1, a bypass south of Harrington, has been ranked of sufficiently high priority so that it will be constructed. This alternative involves building both a new bridge across the Harrington River and a new road connecting U.S. 1A with U.S. 1. The designs for the bridge and road will be prepared. Detailed estimates of the cost to construct will be made, and the project will be announced for bid. The construction company that produces the lowest bid and can meet other qualifications will be awarded the contract, and the road will be built. Upon completion, the road will be turned over to the Department of Transportation, who will be responsible for its maintenance and operation. Follow-up studies will be conducted to determine how successful the road was in meeting its objectives; where necessary, modifications will be made to improve its performance.

11.2 TRANSPORTATION PLANNING INSTITUTIONS

This transportation planning process is based on a systems approach to problem solving and is quite general in its structure. The process is not confined to highways but can be applied to many other situations, such as intercity high-speed rail feasibility studies, airport location, port and harbor development, and urban transportation systems. The most common application is in urban areas, where it has been mandated by law since 1962, when the Federal Aid Highway Act required that all transportation projects in urbanized areas with populations of 50,000 or more be based on a transportation planning process that was continuing, comprehensive, and cooperative, sometimes referred to as the "3C" process. The term *continuing* implies that the process be revisited frequently and viewed as an ongoing concern. *Comprehensive* in this context ensures that all transportation modes are addressed. A *cooperative* process indicates that the state (or states) and all municipalities in an urbanized area work together.

Because the urban transportation planning process provides an institutionalized and formalized planning structure, it is important to identify the environment in which the transportation planner works. The forecasting modeling process that has evolved is presented in Chapter 12 to provide an illustration of the methodology. The planning process used at other problem levels is a variation of this basic approach.

11.2.1 Transportation Planning Organization

In carrying out the urban transportation planning process, several committees represent various community interests and viewpoints. These committees are the policy committee, the technical committee, and the citizens' advisory committee. They also interact with permanent planning entities, such as the regional metropolitan planning organization (MPO).

Policy Committee

The policy committee is composed of elected or appointed officials, such as the mayor and director of public works, who represent the governing bodies or agencies that will be affected by the results. This committee makes the basic policy decisions and acts as a board of directors for the study. Committee members will decide on management aspects of the study as well as key issues of a financial or political nature.

Technical Committee

The technical committee is composed of the engineering and planning staffs that are responsible for carrying out the work or evaluating the technical aspects of the project prepared by consultants. This group will assure that the necessary evaluations and cost comparisons for each project alternative are complete and will supervise the technical details of the entire process. Typically, the technical committee will include highway, transit, and traffic engineers, as well as other specialists in land-use planning, economics, and environmental engineering.

Citizens' Advisory Committee

The citizens' advisory committee is composed of a cross section of the community and may include representatives from labor and business, interested citizens, and members of community interest groups. The committee's function is to express community goals and objectives, to suggest alternatives, and to react to proposed alternatives. Through this committee structure, an open dialogue is facilitated among the policy makers, technical staff, and the community. When a selection is made and recommendations are produced by the study, they should be based on consensus of all interested parties. Although agreement is not always achieved, the citizens' advisory committee serves as a means to increase communication to assure that the final plan which results from the process reflects community interests.

Metropolitan Planning Organization (MPO)

A metropolitan planning organization (MPO) is a transportation policy-making organization made up of representatives from local government and transportation authorities. For example, an MPO representing a city and a county might have a policy board with five voting members: two from the city council, two from the county Board of Supervisors, and one from the state transportation department. The MPO policy board might also include nonvoting members representing various local transit providers, local planning commissions, and other transportation agencies, such as state public transportation departments and the Federal Highway Administration.

11.2.2 Implementation of Transportation Planning Recommendations

There is no single model that represents how each state or region implements projects recommended as a result of the transportation planning process, as implementation is governed by state laws and processes (in addition to federal requirements). Figure 11.6 illustrates how recommendations from the planning process might be implemented in a typical state. There are five relevant processes:

- The *transportation planning process* entails the generation of plans for various types of transportation facilities and programs. Such studies may include a 20-year comprehensive plan created by a regional planning body or specific jurisdiction, project-specific studies of a particular corridor or location, and statewide plans. The creation of these plans typically includes some degree of public involvement, such as public hearings, citizen surveys, or meetings with citizen committees. This process is also guided by federal requirements for state and MPO planning processes. For example, the metropolitan area's long-range plan must be financially constrained such that the projects recommended by the plan do not exceed the forecast for revenue that will be available.
- The *transportation programming process* is the act of reconciling recommended projects from the planning process with the amount of funds available over an expected period of time, usually between three and six years. The transportation program is thus a list of projects and costs that can be supported by the expected revenues.
- The *preliminary engineering* and *right-of-way process* occurs after a project has been selected. Within this process, variations of the alignment may be considered and environmental studies may be conducted, including solicitation of public input through project-specific hearings. The outcome of these environmental studies may result in no change to the project, a decision to implement mitigation measures such as the creation of wetlands to compensate for wetlands destroyed, a modification to the project such as a new alignment, or a termination of the project.
- The *construction process* entails advertising the project, soliciting bids, and constructing the project as well as specifications, construction inspection, and acceptance by the owner.
- The *operations and maintenance* process entails steps to ensure that the investment remains effective, such as pavement management and signal retiming. This phase may also include monitoring of system performance, such as changes in travel time, reliability, or use, which would subsequently influence transportation planning process.

Figure 11.6 illustrates the complexity of the relationship between the transportation planning process and these other project development processes. Clearly, stakeholder involvement does not stop with the completion of a region's transportation

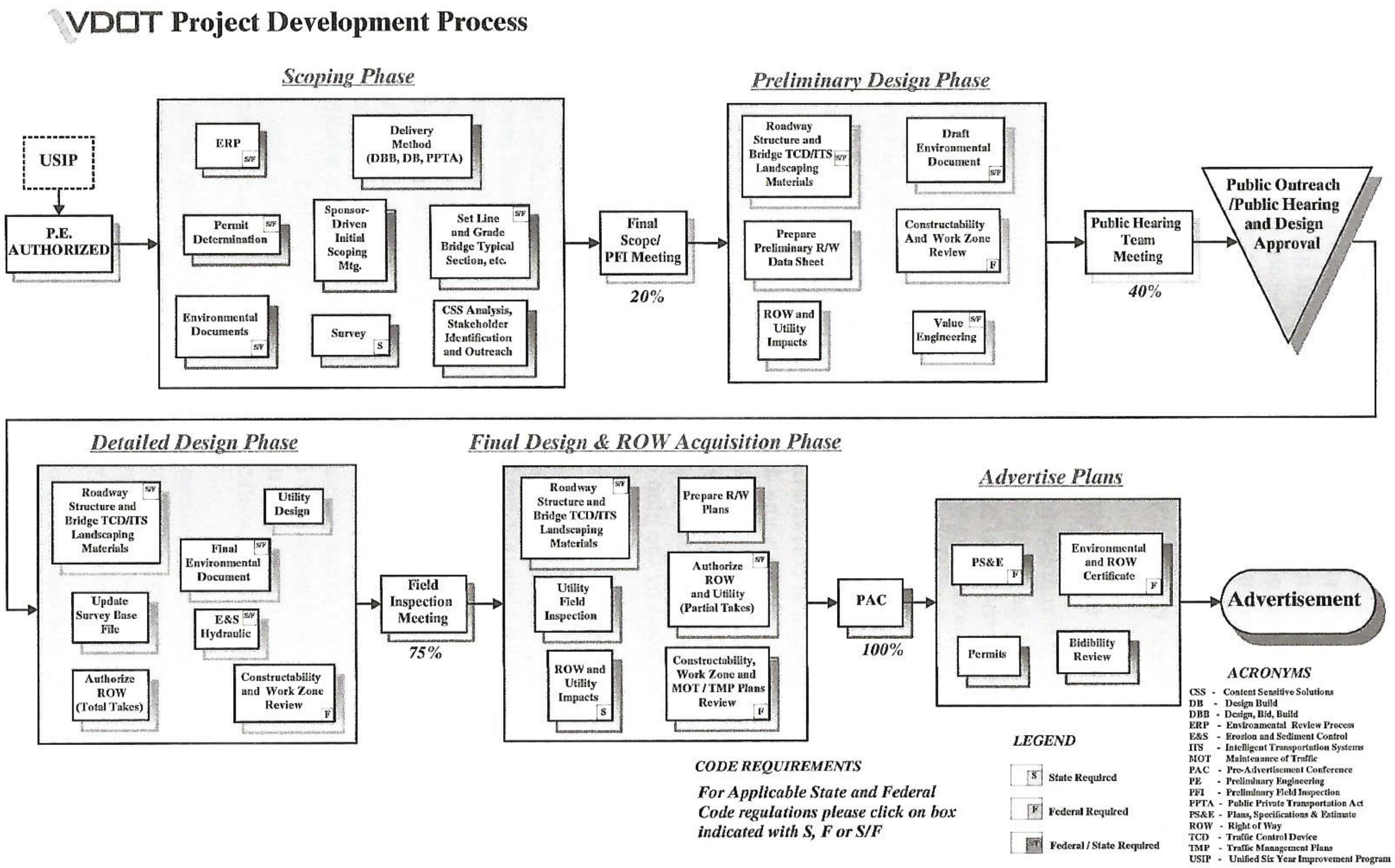


Figure 11.6 Project Development Process

SOURCE: © 2012 Commonwealth of Virginia

plan, meaning there are a variety of opportunities to change the outcome of the plan's recommendations once they have been approved by the MPO and other governing bodies. This figure also illustrates that the practice of transportation planning is incremental, with changes being made until the construction process is underway. There are also a variety of requirements that require coordination of individual bodies in order for a recommendation to be implemented. For example, Figure 11.6 shows that for projects in the MPO area to receive federal funds, the MPO must include the project in its transportation improvement program (TIP), which is a list of projects that the MPO wishes to be undertaken within the next three years (or more). The TIP must be financially constrained; that is, only projects for which funds are available may be placed in the TIP. The TIP in turn is incorporated into the state transportation improvement program (STIP), which is then submitted by the state to FHWA (or FTA) for approval. Finally, the "decision makers" refer to individuals with specific authority at various points throughout the planning, programming, environmental, and construction processes. Decision makers include elected officials in the legislative branches who establish total funds available for the transportation program, special boards that approve the projects that comprise the transportation program, citizens and advocacy groups who influence the outcome of project and program hearings, local and regional officials who make recommendations from their transportation plans, and federal officials who approve projects.

As will be discussed in Section 11.3, the transportation planning process includes operational strategies that can complement or replace traditional capacity expansions. In addition to the TIP and STIP, such operational strategies may be considered through the constrained long-range plan (CLRP) and the region's congestion management process (CMP). Examples of ways to incorporate operations-related initiatives within the transportation planning process include:

- the inclusion of operations-oriented strategies, such as signal retiming, in the TIP
- quantification of the delay reduction impacts of a traffic management system (TMS), thereby enabling it to be compared to delay reduction benefits of a highway investment
- identification of operations-related projects, such as ramp metering, that can delay the need for a more expensive capacity enhancement

11.3 URBAN TRANSPORTATION PLANNING

Urban transportation planning involves the evaluation and selection of highway or transit facilities to serve present and future land uses. For example, the construction of a new shopping center, airport, or convention center will require additional transportation services. Also, new residential development, office space, and industrial parks will generate additional traffic, requiring the creation or expansion of roads and transit services.

The process must also consider other proposed developments and improvements that will occur within the planning period. The urban transportation planning process has been enhanced through the efforts of the Federal Highway Administration and the Federal Transit Administration of the U.S. Department of Transportation by the preparation of manuals and computer programs that assist in organizing data and forecasting travel flows.

Urban transportation planning is concerned with two separate time horizons. The first is a short-term emphasis intended to select projects that can be implemented within a one-to four-year period. These projects are designed to provide better management of existing facilities by making them as efficient as possible. The second time horizon deals with the long-range transportation needs of an area and identifies the projects to be constructed over a 20-year period.

Short-term projects involve programs such as traffic signal timing to improve flow, car and van pooling to reduce congestion, park-and-ride fringe parking lots to increase transit ridership, and transit improvements.

Long-term projects involve programs such as adding new highway elements, additional bus lines or freeway lanes, rapid transit systems and extensions, or access roads to airports or shopping malls.

The urban transportation planning process can be carried out in terms of the procedures outlined previously and is usually described as follows. Figure 11.7 illustrates the comprehensive urban area transportation planning process.

11.3.1 Inventory of Existing Travel and Facilities

This is the data-gathering activity in which urban travel characteristics are described for each defined geographic unit or traffic zone within the study area. Inventories and surveys are made to determine traffic volumes, land uses, origins and destinations of travelers, population, employment, and economic activity. Inventories are made of existing transportation facilities, both highway and transit. Capacity, speed, travel time, and traffic volume are determined. The information gathered is summarized by geographic areas called transportation analysis zones (TAZ).

The size of the TAZ will depend on the nature of the transportation study, and it is important that the number of zones be adequate for the type of problem being investigated. Often, census tracts or census enumeration districts are used as TAZs because population data are easily available by this geographic designation.

11.3.2 Establishment of Goals and Objectives

The urban transportation study is carried out to develop a program of highway and transit projects that should be completed in the future. Thus, a statement of goals, objectives, and standards is prepared that identifies deficiencies in the existing system, desired improvements, and what is to be achieved by the transportation improvements.

For example, if a transit authority is considering the possibility of extending an existing rail line into a newly developed area of the city, its objectives for the new service might be to maximize its revenue from operations, maximize ridership, promote development, and attract the largest number of auto users so as to relieve traffic congestion.

11.3.3 Generation of Alternatives

In this phase of the urban transportation planning process, the alternatives to be analyzed will be identified. It also may be necessary to analyze the travel effects of different land-use plans and to consider various lifestyle scenarios. The options available to the urban transportation planner include various technologies, network configurations, vehicles, operating policies, and organizational arrangements.

In the case of a transit line extension, the technologies could be rail rapid transit or bus. The network configuration could be defined by a single line, two branches, or a geometric configuration such as a radial or grid pattern. The guideway, which represents a homogeneous section of the transportation system, could be varied in length, speed, waiting time, capacity, and direction. The intersections, which represent the end points of the guideway, could be a transit station or the line terminus. The vehicles could

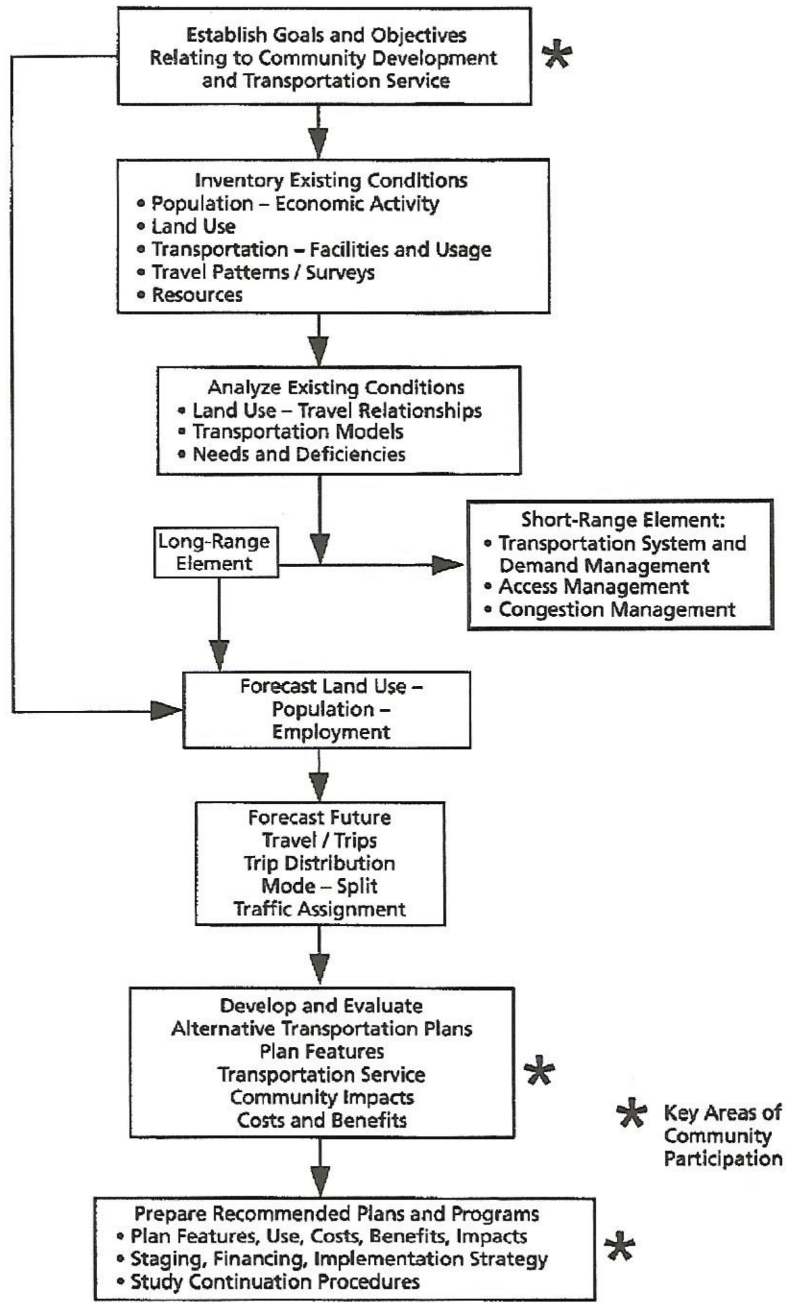


Figure 11.7 Comprehensive Urban Area Transportation Planning Process

SOURCE: Redrawn from *Transportation Planning Handbook*, Institute of Transportation Engineers, 2nd Edition, Institute of Transportation Engineers, 1999. www.ite.org

be singly driven buses or multicar trains. The operating policy could involve 10-minute headways during peak hours and 30-minute headways during off-peak hours, or other combinations. The organizational arrangements could be private or public. These and other alternatives would be considered in this phase of the planning process.

11.3.4 Estimation of Project Cost and Travel Demand

This activity in the urban transportation planning process involves two separate tasks. The first is to determine the project cost, and the second is to estimate the amount of traffic expected in the future. The estimation of facility cost is relatively straightforward, whereas the estimation of future traffic flows is a complex undertaking requiring the use of mathematical models and computers.

Planning-Level Cost Estimation

Project cost estimation at the planning stage may be hampered either because the project has not yet been well defined or because a significant amount of time has passed since the project's cost was previously estimated, rendering the older estimate out of date. To address the first problem, many transportation agencies maintain a set of *unit costs* that allows for a quick determination in the absence of more detailed data. These unit costs may be stratified by area type (rural or urban), number of lanes, and roadway design. For example, one state's unit costs are $5 million/mi of a four-lane divided highway in an urban area with a flat median compared with a cost of about $1 million/mile for a two-lane rural undivided highway. To address the second problem of costs being out of date, cost indices may be used which convert costs from a historical year to a current year by accounting for inflation. The *Consumer Price Index* (CPI) provides an average rate of inflation for all goods and services. Indices specific to the transportation field are the *National Highway Construction Cost Index* (compiled by the Federal Highway Administration for highway construction projects) and various railroad indices, such as the *Railroad Cost Recovery (RCR) Index* or the *All–Inclusive Index–Less Fuel (AII-LF)* (compiled by the American Association of Railroads for railroad projects). If more detailed project cost data are available (e.g., highway labor costs separated from materials costs), then the two previously mentioned sources may be consulted for indices that represent changes for particular goods and services, such as concrete, steel, and labor costs.

Example 11.2 Updating Costs for a Rail Feasibility Study

Table 11.3 shows indices for 2001 and 2005 for railroads, highways, and the *Consumer Price Index.* A study of a freight rail improvement project was completed in 2001 that recommended improvements such as siding, track extension, and track maintenance and estimated a total cost of $120 million in 2001 dollars. The study cost $250,000 to perform, and the state agency would like to convert this cost estimate to 2005 dollars without redoing the entire study. How much should the improvements cost in 2005 dollars?

Solution: Because these are all rail items, the *Railroad Cost Index* is appropriate. This index may be applied as follows:

$$\text{Estimate in 2005 dollars} = (\text{Estimate in 2001 dollars})\,\frac{\text{2005 index}}{\text{2001 index}} \qquad (11.1)$$

Table 11.3 Indices for Railroad Projects, Highway Projects, and Consumer Prices

Index	*Applies to*	*Year 2001*	*Year 2005*
Railroad Index[a]	Rail construction	315.7	356.8
Highway Index[b]	At-grade rail highway crossings	144.8	183.6
Consumer Price Index[c]	All goods and services	177.1	195.3

[a]*American Association of Railroads* (2006) (materials prices, wage rates, and supplements combined, excluding fuel).
[b]*Federal Highway Administration* (2006a) (Federal-Aid Highway Construction Composite Index).
[c]*Bureau of Labor Statistics* (2006) (Consumer Price Index for each year).

$$\text{Estimate in 2005 dollars} = (\$120 \text{ million}) \frac{356.8}{315.7} = \$135.6 \text{ million}$$

Thus, the improvements will cost $136 million in 2005 dollars.

Planning-Level Demand Estimation

Future travel is determined by forecasting future land use in terms of the economic activity and population that the land use in each TAZ will produce. With the land-use forecasts established in terms of number of jobs, residents, auto ownership, income, and so forth, the traffic that this land use will add to the highway and transit facility can be determined. This is carried out in a four-step process that includes the determination of the number of trips generated, the origin and destination of trips, the mode of transportation used by each trip (for example, auto, bus, rail), and the route taken by each trip. The urban travel demand forecasting process thus involves four distinct activities: *trip generation, trip distribution, modal split,* and *network assignment,* as illustrated in Figure 11.8. This forecasting process is described in Chapter 12.

When the travel forecasting process is completed, the highway and transit volumes on each link of the system will have been estimated. The actual amount of traffic, however, is not known until it occurs. The results of the travel demand forecast can be compared with the present capacity of the system to determine the operating level of service.

11.3.5 Evaluation of Alternatives

This phase of the process is similar in concept to what was described earlier but can be complex in practice because of the conflicting objectives and diverse groups that will be affected by an urban transportation project.

Among the groups that could be affected are the traveling public (user), the highway or transit agencies (operator), and the nontraveling public (community). Each of these groups will have different objectives and viewpoints concerning how well the system performs. The traveling public wants to improve speed, safety, and comfort; the transportation agency wishes to minimize cost; and the community wants to preserve its quality of life and improve or minimize environmental impacts.

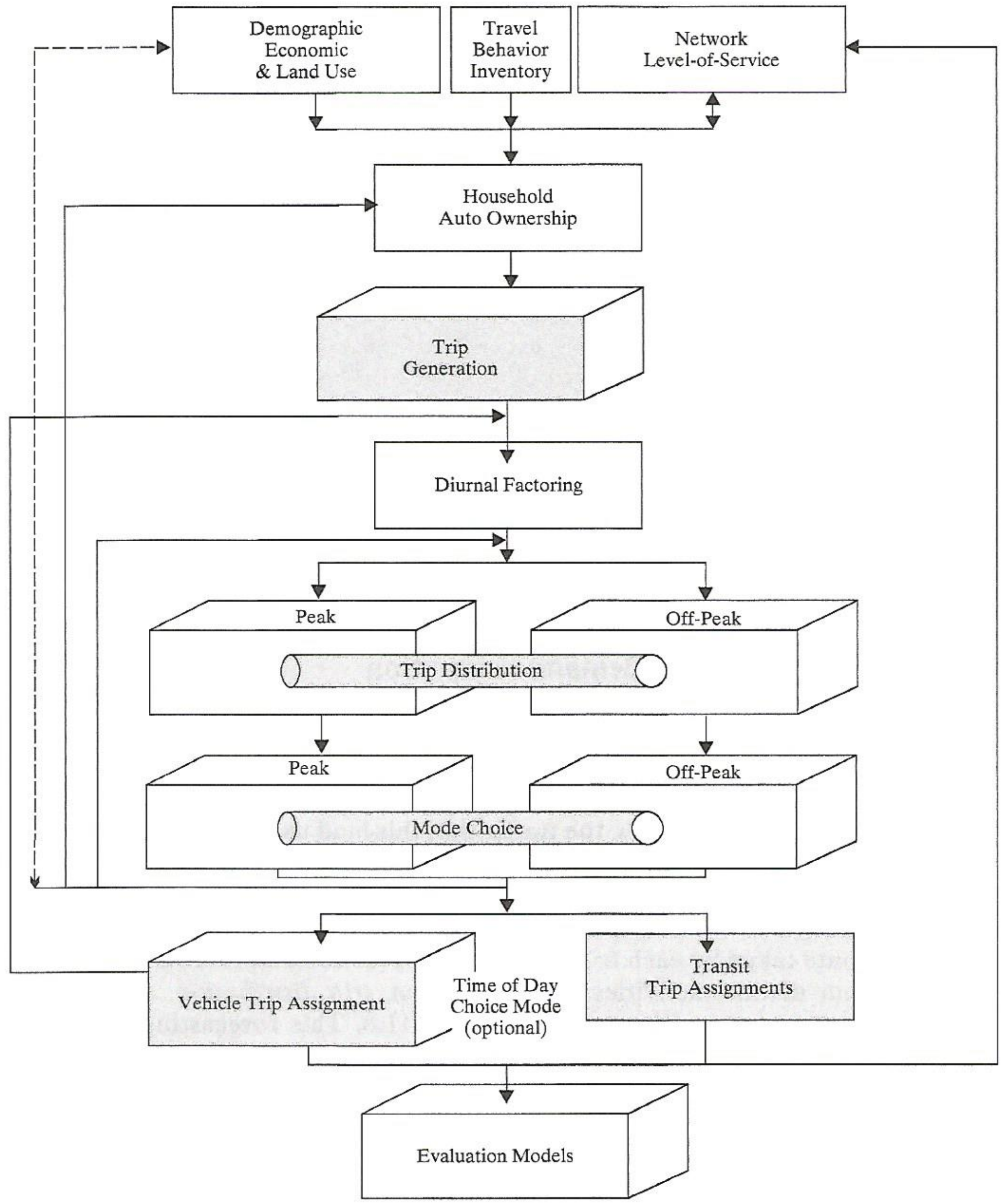


Figure 11.8 Travel Demand Model Flow Chart

SOURCE: *Transportation Planning Handbook*, Third Edition, Institute of Transportation Engineers, 2004. www.ite.org. Used with permission
ITE SOURCE: Atlanta Regional Commission, January 2004

The purpose of the evaluation process is to identify feasible alternatives in terms of cost and traffic capacity, to estimate the effects of each alternative in terms of the objectives expressed, and to assist in identifying those alternatives that will serve the traveling public and be acceptable to the community. Of particular importance are the environmental assessments mandated in most urban transportation studies.

Environmental Impact Statements

Federal and/or state regulations may require that the environmental impacts of proposed projects be assessed. These impacts may include effects on air quality, noise levels, water quality, wetlands, and the preservation of historic sites of interest.

The analytical process through which these effects are identified can take one of three forms, depending on the scope of the proposed project: a full *environmental impact statement* (EIS), a simpler *environmental assessment* (EA), or a cursory checklist of requirements known as a *categorical exclusion* (CE). Examples of projects that might receive the CE designation are utility installations along an existing transportation facility, bicycle lanes, noise barriers, and improvements to rest areas. Generally, projects that receive the CE designation do not require further detailed analysis. Projects for which an EIS is required might include the construction of a new limited-access freeway or a fixed guideway transit line. For some projects, it might not initially be clear whether the project merits a full environmental study. For those projects, an environmental assessment may be conducted, and the EA will either result in a finding of no significant impact (FONSI) or in a finding that a full EIS is warranted. For some large-scale projects that require an EIS, projects may be "tiered." The first tier addresses macroscopic issues, such as whether a proposed facility should be a highway bypass or a light rail line and whether it should follow an eastern or western alignment. The second tier addresses microscopic issues, such as the number of parcels that might be taken once a decision has been made that the facility will be a rail line following a western alignment.

The purpose of this environmental review process is to assure that all potential effects (positive as well as adverse) are addressed in a complete manner so that decision makers can understand the consequences of the proposed project. Once an agency, such as a state department of transportation, completes a draft EIS, the public is given an opportunity to comment. The project cannot proceed until the revised, final EIS has been accepted by the appropriate federal and state regulatory agencies. Generally, these federal regulatory agencies will include FHWA and FTA.

Elements of an EIS

Although the entire environmental review process is beyond the scope of this text, examination of some of the common elements of an EIS illustrate its role in transportation planning.

The project's *purpose and need* section articulates why the project is being undertaken: Is it to improve safety, to increase capacity in response to expected future traffic growth, or is it to upgrade a deficient link in a region's comprehensive transportation network? The purpose and need section should include relevant AADT projections, crash rates, and a description of existing geometric conditions.

The *alternatives* to the proposed project, such as the do-nothing case, should be described, as well as any criteria that have been used to eliminate alternatives from further consideration. For example, if a second bridge crossing over a body of water is being considered, then alternatives could be to change the location, to widen an existing bridge, to improve ferry service, or to do nothing. Criteria that prevent further consideration, such as the presence of an endangered species at what would have been another potential location or the permanent loss of several acres of wetlands, are given in this section.

The *environmental effects* of the proposed project, such as the impacts on water quality (during construction and once construction is complete), soil, wetlands, and plant and animal life, especially endangered species, should be analyzed. Note that environmental effects also include the impact on communities, such as air quality, land use, cultural resources, and noise.

Computing Environmental Impacts for Emissions and Noise

The level of detail in a full EIS can be staggering given the amount of analysis required to answer some seemingly simple questions: What is the noise level? How much will automobile emissions increase?

A number of tools are provided by regulatory agencies that can answer some of these questions. For example, the Environmental Protection Agency (EPA) has developed the Motor Vehicle Emissions Simulator (MOVES) model, which estimates emissions for mobile sources such as cars and trucks. The results of this model, compared with observed carbon monoxide concentrations, can be used to determine the relative impact of different project alternatives on the level of carbon monoxide.

One approach for quantifying noise impacts is to use the Federal Highway Administration's Transportation Noise Model (TNM), a computer program that forecasts noise levels as a function of traffic volumes and other factors. The method by which noise impacts are assessed can vary by regulatory agency. For example, the FHWA will permit one to use the L_{10} descriptor, which is "the percentile noise level that is exceeded for ten percent of the time." A more common noise descriptor is L_{eq}, which is the average noise intensity over time. A variant of this descriptor may be used by the U.S. Department of Housing and Urban Development (HUD), where the L_{eq} for each hour is determined but then a 10-dB "penalty" is added to the values from 10 p.m. to 7 a.m. Since noise is proportional to traffic speed, the impact of this last type of descriptor is to favor projects that would not necessarily result in high speeds in close proximity to populated areas during the evening hours.

An EIS utilizes current and forecasted volume counts (i.e., automobiles, medium trucks, and heavy trucks), speeds, and directional split in order to compare environmental effects for the current conditions, future conditions with the proposed project, and future conditions assuming any other alternatives, which at a minimum should include the no-build option.

11.3.6 Choice of Project

Selection of a project will be based on a process that will ultimately involve elected officials and the public. Quite often, funds to build an urban transportation project (such as a subway system) may involve a public referendum. In other cases, a vote by a state legislature may be required before funds are committed. A multiyear program then will be produced that outlines the projects to be carried out over the next 20 years. With approval in hand, the project can proceed to the specification and construction phase.

11.4 FORECASTING TRAVEL

To accomplish the objectives and tasks of the urban transportation planning process, a technical effort referred to as the *urban transportation forecasting process* is carried out to analyze the performance of various alternatives. There are four basic elements and related tasks in the process: (1) data collection (or inventories), (2) analysis of existing conditions and calibration of forecasting techniques, (3) forecast of future travel demand, and (4) analysis of the results. These elements and related tasks are described in the following sections.

11.4.1 Defining the Study Area

Prior to collecting and summarizing the data, it is usually necessary to delineate the study area boundaries and to further subdivide the area into transportation analysis zones (TAZ) for data tabulation. An illustration of traffic analysis zones for a transportation study is shown in Figure 11.9. The selection of these zones is based on the following criteria:

1. Socioeconomic characteristics should be homogeneous.
2. Intrazonal trips should be minimized.
3. Physical, political, and historical boundaries should be utilized where possible.
4. Zones should not be created within other zones.

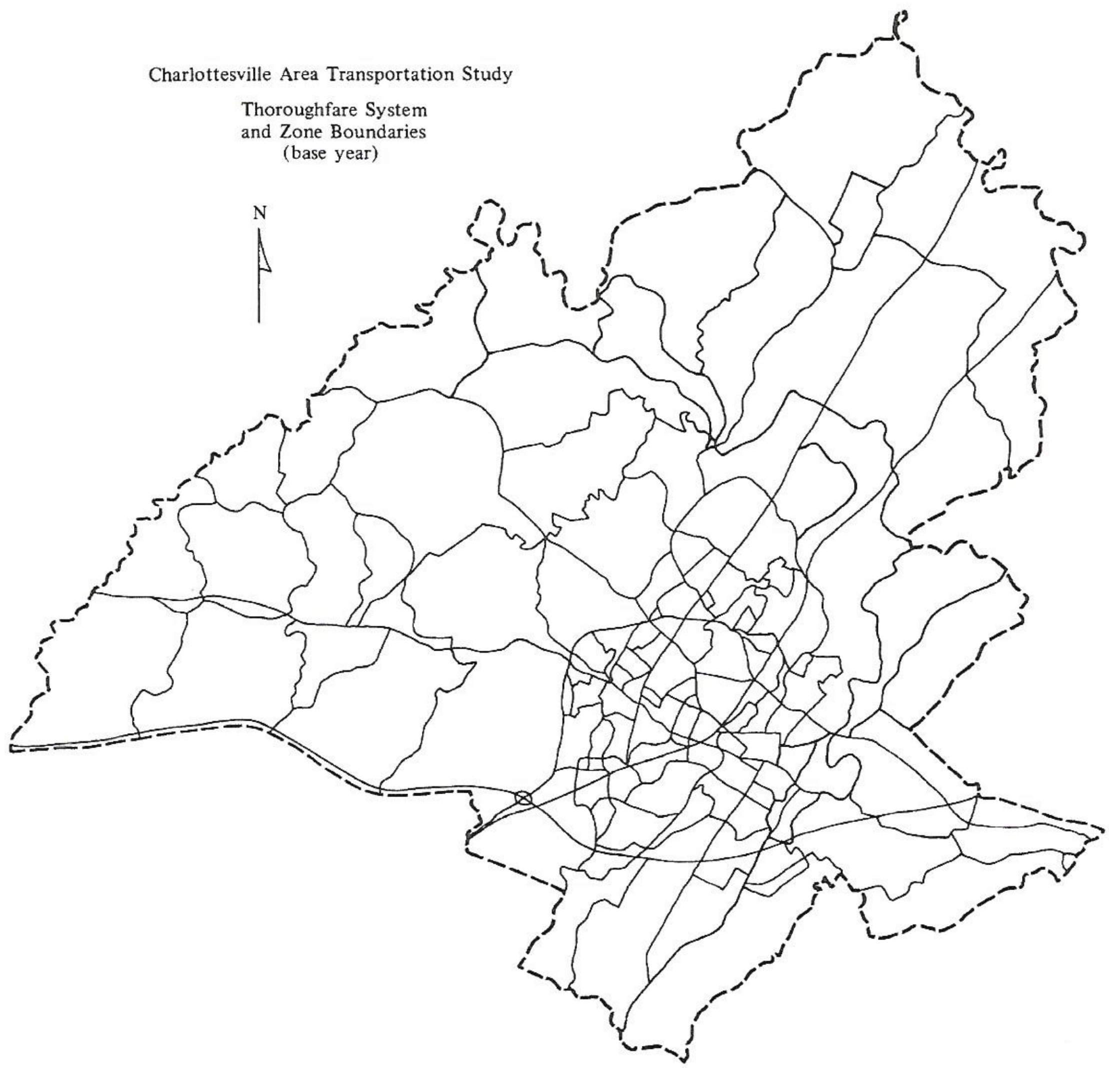


Figure 11.9 Traffic Analysis Zones for Transportation Study

SOURCE: © 1985 Commonwealth of Virginia

5. The zone system should generate and attract approximately equal trips, households, population, or area. For example, labor force and employment should be similar.
6. Zones should use census tract boundaries where possible.

It may be necessary to exercise some judgment in determining the total number of zones. For example, one guideline for establishing the total number within a study area is that there should be, on average, one zone per 1000 people (such that an area with 500,000 people would have 500 total zones). The internal trip table for such a study area will thus have $500 \times 500 = 250{,}000$ cells (e.g., trips from zone 1 to zone 1, trips from zone 1 to zone 2, trips from zone 1 to zone 3, and so forth). By comparison, suppose the study area has a population of 2 million. Application of the 1000 people/zone guideline would yield 2000 total zones and thus $2000 \times 2000 = 4$ million cells for the internal trip table, which requires substantially more computing power and time to process.

Agencies may provide some guidance for achieving these six criteria. Examples of such guidance are as follows: there is an average of 1000 people/zone for smaller areas, a ratio of between 0.9 and 1.1 for productions to attractions, no more than 10,000 trips should be generated for a given zone, and a ratio of labor force to employment must be at least 0.80. Such guidelines do not constitute absolute standards but rather represent a compromise between an ideal data set and available resources for data collection and processing.

11.4.2 Data Collection

The data collection phase provides information about the city and its people that will serve as the basis for developing travel demand estimates. The data include information about economic activity (employment, sales volume, income, etc.), land use (type, intensity), travel characteristics (trip and traveler profile), and transportation facilities (capacity, travel speed, etc.). This phase may involve surveys and can be based on previously collected data.

11.4.3 Population and Economic Data

Once a zone system for the study area is established, population and socioeconomic forecasts prepared at a regional or statewide level are used. These are allocated to the study area, and then the totals are distributed to each zone. This process can be accomplished by using either a ratio technique or small-area land-use allocation models.

The population and economic data usually will be furnished by the agencies responsible for planning and economic development, whereas providing travel and transportation data is the responsibility of the transportation engineer. For this reason, the data required to describe travel characteristics and the transportation system are described as follows.

11.4.4 Transportation Inventories

Transportation system inventories involve a description of the existing transportation services; the available facilities and their condition; location of routes and schedules; maintenance and operating costs; system capacity and existing traffic; volumes, speed, and delay; and property and equipment. The types of data collected about the current system will depend on the specifics of the problem.

For a highway planning study, the system would be classified functionally into categories that reflect their principal use. These are the major arterial system, minor arterials, collector roads, and local service (see Chapter 15). Physical features of the road system would include number of lanes, pavement and approach width, traffic signals, and traffic-control devices. Street and highway capacity would be determined, including capacity of intersections. Traffic volume data would be determined for intersections and highway links. Travel times along the arterial highway system would also be determined.

A computer model of the existing street and highway system is produced. The network consists of a series of links, nodes, and centroids (as illustrated in Figure 11.10). A *link* is a portion of the highway system that can be described by its capacity, lane width, and speed. A *node* is the end point of a link and represents an intersection or location where a link changes direction, capacity, width, or speed. A *centroid* is the location within a zone where trips are considered to begin and end. Coding of the network requires information from the highway inventory in terms of link speeds, length, and capacities. The network is then coded to locate zone centroids, nodes, and the street system.

Figure 11.11 shows *external stations*, which are established at the study area boundary. External stations are those roadways where traffic is likely to enter or exit the study area, such as primary and interstate facilities, and are used to account for the impact of changes outside the study area on the travel network within the study area.

For a transit planning study, the inventory includes present routes and schedules, including headways, transfer points, bus stops, terminals, and parking facilities. Information about the bus fleet, such as its number, size, and age, are identified. Maintenance facilities and maintenance schedules are determined, as are the organization and financial condition of the transit companies furnishing service in the area. Other data includes revenue and operating expenses.

The transportation facility inventories provide the basis for establishing the networks that will be studied to determine present and future traffic flows. Data needs can include the following items:

- Public streets and highways
  - Rights-of-way
  - Roadway and shoulder widths
  - Locations of curbed sections
  - Locations of structures such as bridges, overpasses, underpasses, and major culverts
  - Overhead structure clearances
  - Railroad crossings
  - Location of critical curves or grades
  - Identification of routes by governmental unit having maintenance jurisdiction
  - Functional classification
  - Street lighting
- Land-use and zoning controls
- Traffic generators
  - Schools
  - Parks
  - Stadiums
  - Shopping centers
  - Office complexes
- Laws, ordinances, and regulations
- Traffic-control devices

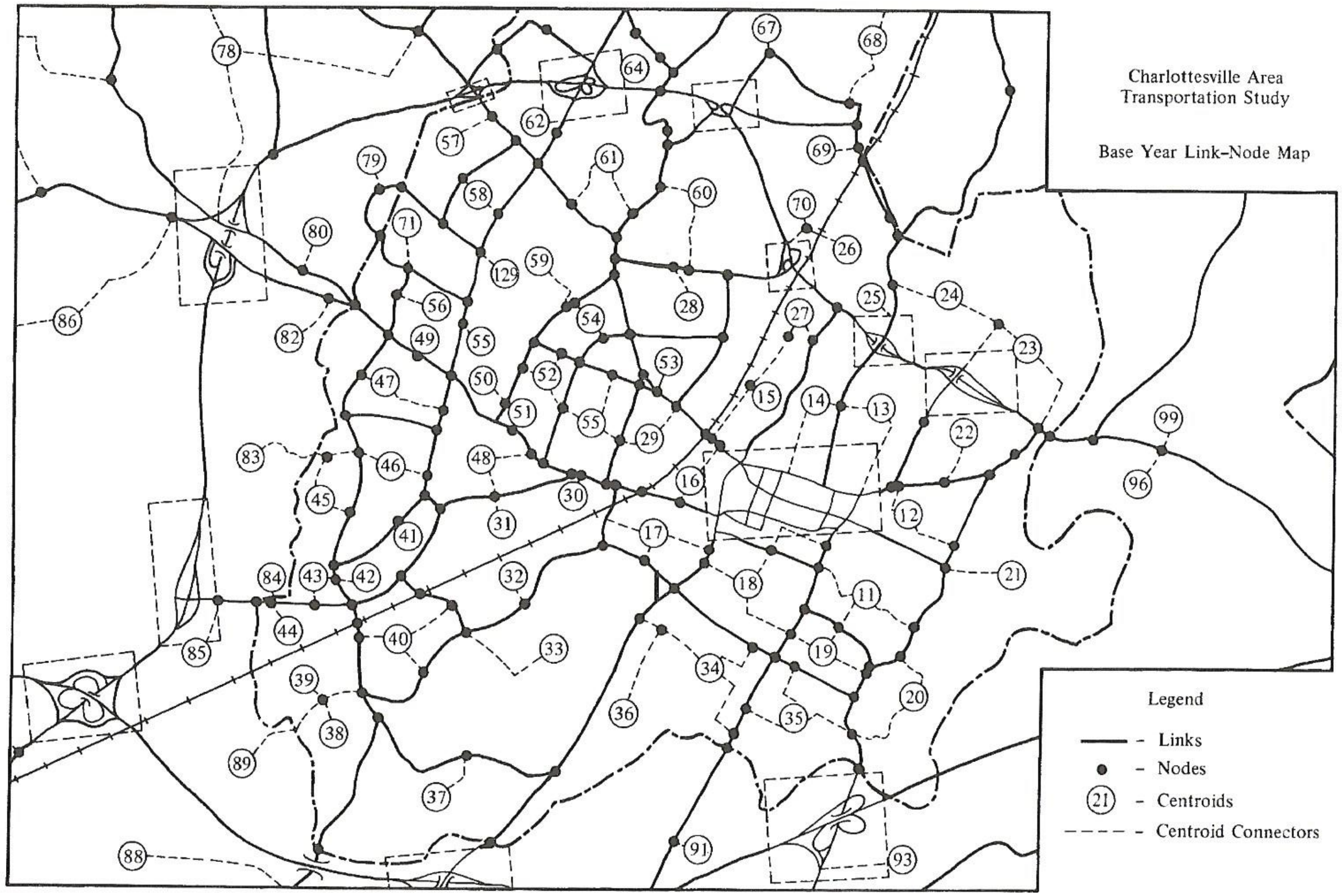


Figure 11.10 Link-Node Map for Highway System

SOURCE: © 1985 Commonwealth of Virginia

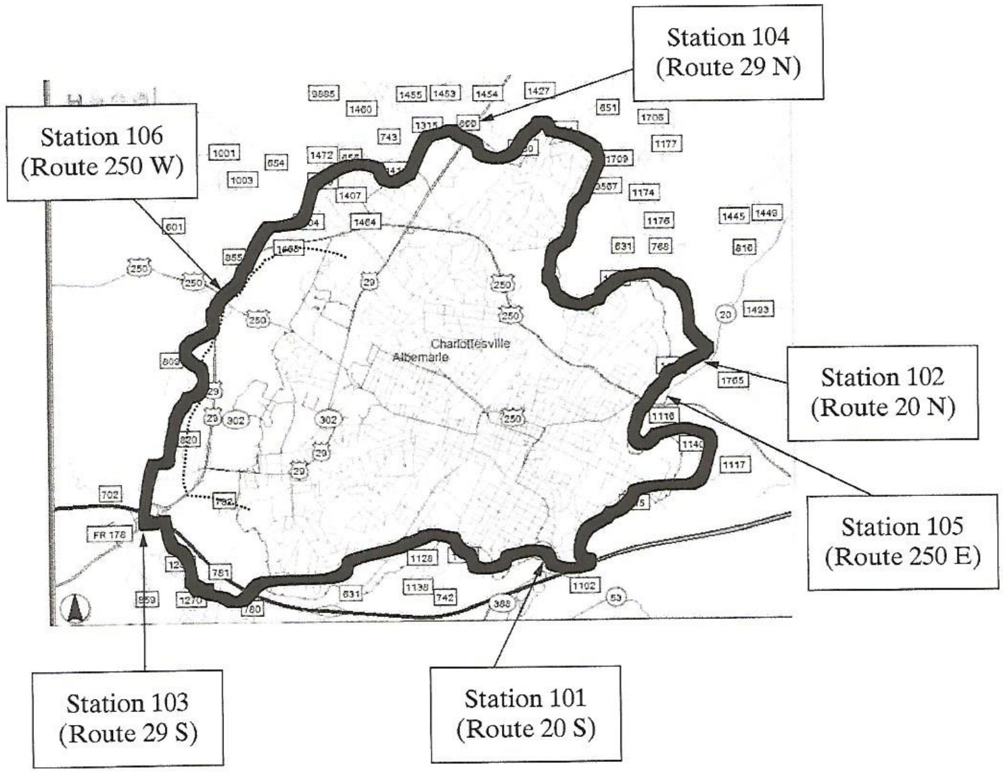


Figure 11.11 External Stations for a Study Area Boundary

SOURCE: Based on Virginia Department of Transportation GIS Integrator

  - Traffic signs
  - Signals
  - Pavement markings
- Transit system
  - Routes by street
  - Locations and lengths of stops and bus layover spaces
  - Location of off-street terminals
  - Change of mode facilities
- Parking facilities
- Traffic volumes
- Travel times
- Intersection and roadway capacities

In many instances, the data will already have been collected and are available in the files of city, county, or state offices. In other instances, some data may be more essential than others. A careful evaluation of the data needs should be undertaken prior to the study.

11.4.5 Information Systems

Almost all network data are organized within some type of Geographic Information System (GIS). A GIS is a spatially oriented database management system containing location and attribute information for synthetic and natural features and supporting related queries with these features. This description, however, does not explain why GIS has become such an integral component of transportation planning that, as is the case with word processors and spreadsheets, GIS is simply viewed as another practical instrument rather than a separate topic of study. There are three reasons that explain the popularity of GIS for transportation planning.

First, a GIS is scaleable, meaning it may support analysis for a wide range of geographic scales, ranging from the macroscopic level of a state or region to the microscopic level of a single neighborhood. Applications at the state or regional level include modifying the zone structure (e.g., aligning transportation analysis zone boundaries with manmade or natural boundaries), obtaining needed socioeconomic data for regional travel demand models (e.g., population, employment, household size, income, or other indicators of travel demand), or determining the rail facilities within 100 miles of a freight generator. By comparison, microscopic-scale queries are often specific to a single neighborhood or transportation project and may include a determination of how the project impacts community centers, parks, schools, and ecological resources such as conservation areas and wetlands. The scalability of this information means that the same information may be used for multiple purposes. For example, a sidewalk quality survey may support both a current maintenance program (dictating which missing sidewalk links should be repaired first) and future pedestrian travel demand estimation.

Second, a GIS contains information used by other professions, enabling planners to access data that already have been collected for other purposes. For example, a county assessor's office may have tax records for various residential parcels, including the square footage of each structure, its appraised value, its street address, and the residential density (e.g., number of dwellings per acre). Although these tax maps may have been created primarily for the purpose of tax assessment, knowledge of the housing density and price may enable the transportation planner to more accurately estimate the number of automobile trips that will be generated by a neighborhood (since such trips are affected by factors that include housing density and personal wealth). GIS data are thus available from a variety of public and private sources. For example, the Census Bureau provides Topologically Integrated Geographic Encoding and Referencing (TIGER) line files that include transportation facilities (streets, highways, and rail lines), community landmarks (schools and hospitals), environmental features (water, streams, and wetlands), and jurisdictional information (boundaries and census tracts).

Third, a GIS offers strong spatial analytical capabilities that make use of the point, line, and area features contained within the GIS. For example, to investigate the possibility of runoff from transportation facilities affecting wetlands, an analyst may create a 200-meter (656-ft) buffer around a region's roads and identify any wetlands within that buffer. Such a query is known as a line/area query, since the highways are line features (defined by a series of segments) and the wetlands are an area feature (defined by a polygon). In addition to line features (e.g., streams, rivers, highways, or rail lines) and area features (e.g., cities, counties, lakes, or forests), a GIS may also contain point features (e.g., historic churches, community centers, or wildlife crossings). These features support other types of queries besides those shown in Figure 11.12, such as tabulating the number of persons within one-half mile of a heavy rail stop (a point/area query), identifying unforested lands that are not within a county's development plan (an area/area query), or determining the number of alternative routes between two points (a network analysis query).

The versatility of GIS to incorporate data from a variety of sources means that substantial data cleansing may be necessary for some applications when GIS data are

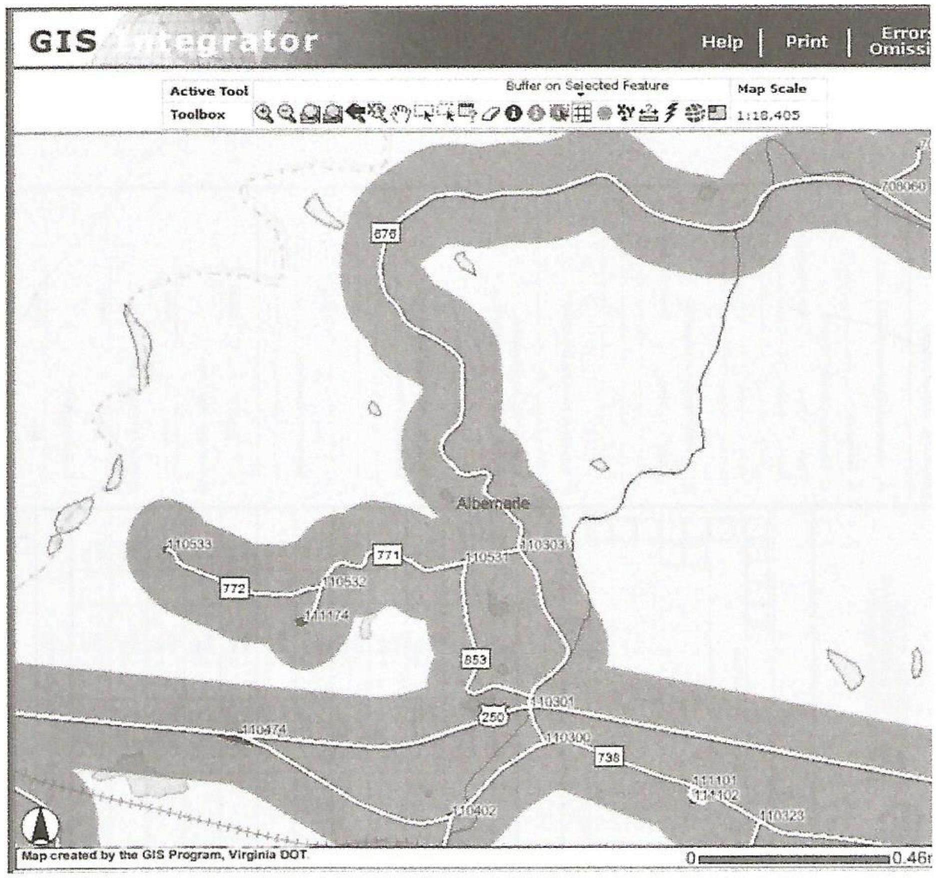


Figure 11.12 GIS Buffer Analysis to Identify Wetlands Impacted by Roadways

SOURCE: Created by using GIS tools within the Virginia Department of Transportation GIS Integrator

imported from other sources. For example, one state's GIS had a grade-separated overpass initially represented as an at-grade intersection (because the GIS had initially not been developed for the purposes of network analysis). Thus, each intersection was reviewed to ensure that representation within the GIS matched intersections in the field.

11.4.6 Travel Surveys

Travel surveys are conducted to establish a complete understanding of the travel patterns within the study area. For single projects (such as a highway project), it may be sufficient to use traffic counts on existing roads or (for transit) counts of passengers riding the present system. However, to understand why people travel and where they wish to go, origin-destination (O-D) survey data can be useful. The O-D survey asks questions about each trip that is made on a specific day—such as where the trip begins and ends, the purpose of the trip, the time of day, and the vehicle involved (auto or transit)—and about the person making the trip—age, sex, income, vehicle owner, and so on. Figure 11.13 illustrates a home interview origin-destination survey form. The O-D survey may be completed as a home interview, or people may be asked questions

Travel Day ______ and Date [ ][ ][ ]

Sample Number [ ][ ][ ][ ]

NORTH CENTRAL TEXAS
COUNCIL OF GOVERNMENTS
HOME INTERVIEW SURVEY

Section I: Household Data

A. Sample Address ______ House Number, Street Name, Apt. No. ______ City/Town ______ County ______ Zip Code [ ][ ][ ][ ][ ]

B. Structure Type ______ [ ]

C. Number of People Living at this Address ______ [ ][ ]

D. Number of People Age 5 and Over Living at this Address ______ [ ][ ]

E. Number of Out-of-Area Visitors Staying at this Address ______ [ ]

F. Number of Passenger Cars, Vans, and Pickups Available for Use ______ [ ]

G. Household Income: (Do Not Ask Until Interview Is Complete) ______ [ ]

Section II: Data on Persons Age 5 and Over

A	B	C	D	E	F	G	H	I	J	K
Person Number	✓ If Interviewed	Relation To Head	Age	Sex	Licensed to Drive?	Occupation	Industry	Worked on Travel Day?	Made Trips While at Work?	Made Other Trips on Travel Day?
01		Head [1]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
02		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
03		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
04		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
05		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
06		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
07		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
08		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
09		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO
10		[ ]	[ ]	1 M 2 F	1 YES 2 NO	[ ][ ]		1 YES 2 NO 3 Worked at Home	1 YES 2 NO	1 YES 2 NO

Age Codes

1 5 - 10	6 36 - 45
2 11 - 15	7 46 - 55
3 16 - 20	8 56 - 65
4 21 - 25	9 65 - OVER
5 26 - 35	0 UNKNOWN

Relation Codes

1 HEAD	6 GRANDCHILD
2 SPOUSE	7 OTHER RELATIVE
3 SON	8 UNRELATED
4 DAUGHTER	9 OUT-OF-AREA VISITORS
5 GRANDPARENT	0 UNKNOWN

Section III: Trip Summary

A. Total Vehicular Trips Reported ______ [ ][ ][ ]

B. Persons Age 5 and Over Making Trips ______ [ ][ ]

C. Persons Age 5 and Over Not Making Trips ______ [ ][ ]

D. Complete or Incomplete Interview Code ______ [ ]

Section IV: Administrative

A. Household Telephone Number ______

B. Interviewer ______

C. Telephone Contacts (If Any) :

Date	Time	Purpose/Outcome

D. Personal Contacts In Household:

Date	Time	Talked To/Comments

E. Completed Interview Submitted:

Date: ______ By: ______

I Certify That All Information On This Form Is Correct And True.

______
Signature of Interviewer

F. If Interview Submitted Incomplete

Interviewer's Reason: ______

______ Date ______ Initials

Supervisor's Comments ______

______ Date ______ Initials

G. First Edit: Fail Pass

______ Date ______ Initials

H. Final Edit: Fail Pass

______ Date ______ Initials

I. Coding Complete

______ Date ______ Initials

Figure 11.13 Travel Behavior Inventory: Home Interview Survey

SOURCE: North Central Texas Council of Governments while riding the bus or when stopped at a roadside interview station. Sometimes, the information is requested by telephone, by return postcard, by e-mail, and by the Internet. O-D surveys are rarely completed in communities where these data have been previously collected. Due to their high cost, O-D surveys are being replaced by using U.S. Census travel-to-work data.

O-D data are compared with other sources to ensure the accuracy and consistency of the results. Among the comparisons used are crosschecks between the number of dwelling units or the trips per dwelling unit observed in the survey with published data. Screenline checks (see Chapter 4) can be made to compare the number of reported trips that cross a defined boundary, such as a bridge or two parts of a city, with the number actually observed. For example, the number of cars observed crossing one or more bridges might be compared with the number estimated from the surveys. It is also possible to assign trips to the existing network to compare how well the data replicate actual travel. If the screenline crossings are significantly different from those produced by the data, it is possible to make adjustments in the O-D results so that conformance with the actual conditions is assured.

Following the O-D checking procedure, a set of trip tables is prepared that shows the number of trips between each zone in the study area. These tables can be subdivided, for example, by trip purpose, truck trips, and taxi trips. Tables are also prepared that list the socioeconomic characteristics for each zone and the travel time between zones. Examples of trip tables are shown in Chapter 12.

11.4.7 Calibration

Calibration is concerned with establishing mathematical relationships that can be used to estimate future travel demand. Usually, analysis of the data will reveal the effect on travel demand of factors such as land use, socioeconomic characteristics, or transportation system factors.

Example 11.3 Estimating Trips per Day Using Multiple Regression

A multiple regression analysis shows the following relationship for the number of trips per household.

$$T = 0.82 + 1.3P + 2.1A$$

where

T = number of trips per household per day
P = number of persons per household
A = number of autos per household

If a particular TAZ contains 250 households with an average of 4 persons and 2 autos for each household, determine the average number of trips per day in that zone.

Solution:

Step 1. Calculate the number of trips per household.

$$T = 0.82 + 1.3P + 2.1A$$
$$= 0.82 + (1.3 \times 4) + (2.1 + 2)$$
$$= 10.22 \text{ trips/household/day}$$

Step 2. Determine the number of trips in the entire zone.

$$\text{Total trips in TAZ} = 250\,(10.22) = 2555 \text{ trips/day}$$

Other mathematical formulas establish the relationships for trip length, percentage of trips by auto or transit, or the particular travel route selected.

Travel forecasts are made by applying the relationships developed in the calibration process. These formulas rely upon estimates of future land use, socioeconomic characteristics, and transportation conditions.

11.4.8 Steps in the Travel Forecasting Process

Forecasting can be summarized in a simplified way by indicating the task that each step in the process is intended to perform. These tasks are as follows (and are described more fully in Chapter 12).

Step 1. **Population and economic analysis** determines the magnitude and extent of activity in the urban area.

Step 2. **Land-use analysis** determines where the activities will be located.

Step 3. **Trip generation** determines how many trips each activity will produce or attract.

Step 4. **Trip distribution** determines the origin or destination of trips that are generated at a given activity.

Step 5. **Modal split** determines which mode of transportation will be used to make the trip.

Step 6. **Traffic assignment** determines which route on the transportation network will be used when making the trip where each user seeks to minimize their travel time on the network.

Computers are used extensively in the urban transportation planning process. A package of programs was developed by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA), called the Urban Transportation Planning System (UTPS). The techniques have been computerized, and various versions of the original UTPS program are now available from private vendors. Because the data requirements for applying travel-demand software are substantial, the ability to use a package to import data from other sources is an important consideration in choosing such software. A separate class of computer software packages has been developed to give rough estimates of travel demand and the resultant impact on the transportation network. These packages are known as sketch planning methods and are designed to work as a supplement to the travel-demand packages. One example is the Surface

Transportation Efficiency Analysis Module (STEAM), which provides estimates of the impact various alternatives will have on delay, emissions, accidents, and user costs such as fuel consumption and parking.

11.4.9 Transportation and Land-Use Coordination

Because transportation is a desired demand, decision makers may be interested in evaluating how alternative land-use policies may influence this demand. Such policies may take the form of regulations, incentives, or both.

- *Concurrency requirements* are a regulatory technique where a state or locale requires that sufficient transportation infrastructure be present to accommodate anticipated growth. One mechanism through which a state may implement concurrency is to require that localities adopt a set of performance standards for various transportation facilities in the county. For roadways, these standards may be based on level of service, functional classification, and location; for example, a locale may set a performance standard of LOS B for principal arterials in rural areas and a standard of E for minor collectors in urban areas. Standards may also reflect transit or bicycle performance through the use of service frequency or breadth of coverage, respectively. When new developments are proposed, a *traffic impact assessment* is undertaken to determine whether the new development will still permit the performance standard to be obtained. If not, improvements may be required, such as roadway widening, transit service expansion, signal coordination, the construction of bicycle lanes, or other steps that will mitigate the travel impacts of the new development.
- *Grants for public and private entities* are examples of incentives. In contrast with residential development, commercial sites tend to generate more tax revenue than what they require in the form of services, which may encourage localities to have zoning that favors commercial over residential development. It is possible that such a situation may result in longer commuting distances if workers are unable to find affordable housing in proximity to their employment. To encourage an increase in housing stock in areas that have relatively high employment, grants may be provided by a state to localities which (1) have a relatively high ratio of jobs to housing and (2) issue a certain number of residential building permits. Grants may also be provided to the private sector; for example, a locale may permit developers to build extra office space for each increment of housing they provide.
- *Priority funding areas* are a mix of regulations and incentives. For example, in an effort to limit or manage the geographical growth of an urban area, a state may require that certain types of transportation investments, such as state-funded infrastructure capacity expansions, only be undertaken in regions that meet criteria in terms of residential density, water and sewer availability, or other indicators of land development. An illustration is Maryland's 1997 Smart Growth Areas Act, which required that major capacity-expansion construction projects, excluding toll facilities, be restricted to priority funding areas (PFAs). One criterion that counties could use to designate a PFA located outside an existing community was that the area must have densities equal to or greater than 3.5 dwelling units per acre.

A common element of these policies is that they provide guidance for public and private sector entities to plan for transportation systems that achieve one or more policy objectives. This guidance may also pertain to how highways are designed and managed. For example, consider the importance of access control on arterial multilane highways. The extent to which this control is managed clearly influences safety, where facilities with full access control have a crash rate that is approximately one-third that of non-access controlled facilities. State and local agencies have an interest in minimizing the need for new access points along an arterial facility and the volume of vehicles using these new access points. An agency may establish a policy that when new residential developments are constructed along an arterial facility, these new developments should have multiple connections between developments rather than having each development be accessible only from the arterial facility. Such a gridded network of streets may reduce the number of local trips on the arterial facility.

Connectivity requirements are one tool an agency may use to implement this policy of a gridded street network. When residential subdivisions and streets are constructed, a landowner may petition the state or county to assume responsibility for maintaining these streets. The public agency may then use connectivity requirements as a factor in deciding whether or not to accept maintenance responsibilities for such streets. Such requirements may concern the extent to which the streets are aligned in a grid pattern as opposed to a dendritic pattern, pedestrian considerations, and interconnections between properties (e.g., a series of highly interconnected streets within a subdivision that do not provide access to any other properties except via a single connection to an arterial highway are not likely to meet the requirements). For a privately built residential development, ways to measure connectivity include, but are not limited to,

- the number of intersections with an external roadway network
- the availability of sidewalks, trails, or other nonmotorized facilities between the development and other developments, businesses, or cultural sites
- an ability to provide future connections to the external roadway network, such as preservation of street end points that can be extended when new properties are developed

Example 11.4 Computing a Connectivity Index

A proposed residential development is shown in Figure 11.14a. The jurisdiction in which this parcel is located requires that new residential streets be privately maintained unless the proposed development will have a connectivity index of 1.5 or higher, where the connectivity index is defined by Eq. 11.2. Compute the connectivity index of the proposed development, indicate how the index can be increased to the required threshold of 1.5, and give one dimension of connectivity not quantified by the index.

$$CI = \frac{\text{Segments}}{\text{Nodes}} \tag{11.2}$$

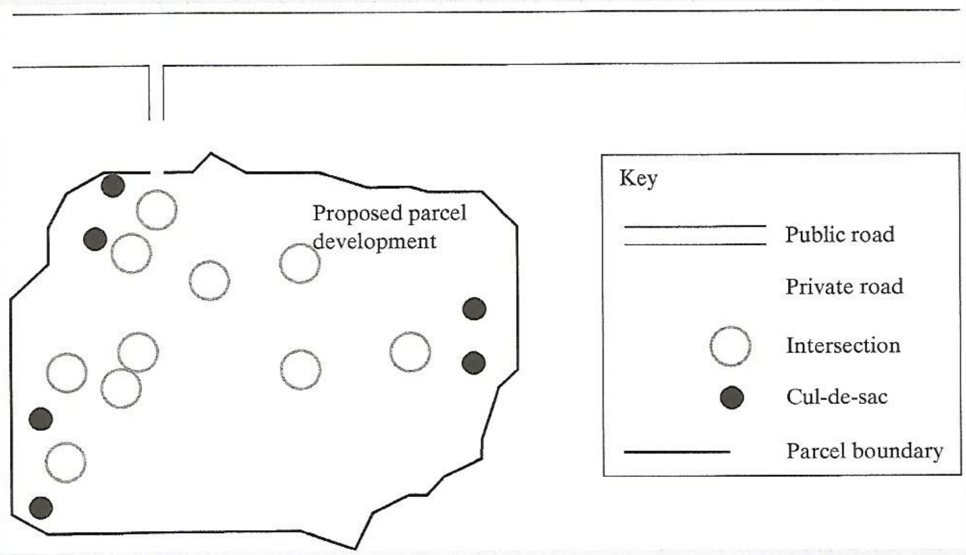


Figure 11.14a Proposed Parcel Development (Original Proposal)

where

CI = connectivity index

Nodes = intersection with another private street or cul-de-sac

Segments = section of street between two nodes or between one node and the boundary of the private development

Solution:

Figure 11.14a shows 10 intersections and 6 cul-de-sacs, so there are 16 nodes. Figure 11.14b shows 20 segments. The connectivity index is therefore

$$CI = \frac{20 \text{ Segments}}{16 \text{ Nodes}} = 1.25$$

To raise the connectivity index to the required threshold of 1.5, one solution is to convert three of the cul-de-sacs to through streets as shown in Figure 11.14b, thereby reducing the number of nodes from 16 to 13. By extending segments 1, 13, and 17 to the boundary of the development for connection to future (as of yet unbuilt) street networks, the connectivity index will rise to 20/13 = 1.54.

This particular connectivity index does not measure the extent to which sidewalks, trails, and other amenities facilitate nonmotorized travel between this and adjacent developments. Further, this index does not differentiate between connections to existing and proposed developments. Such differentiation might affect residents if, for example, segment 1 connects to an existing business area whereas the area to the

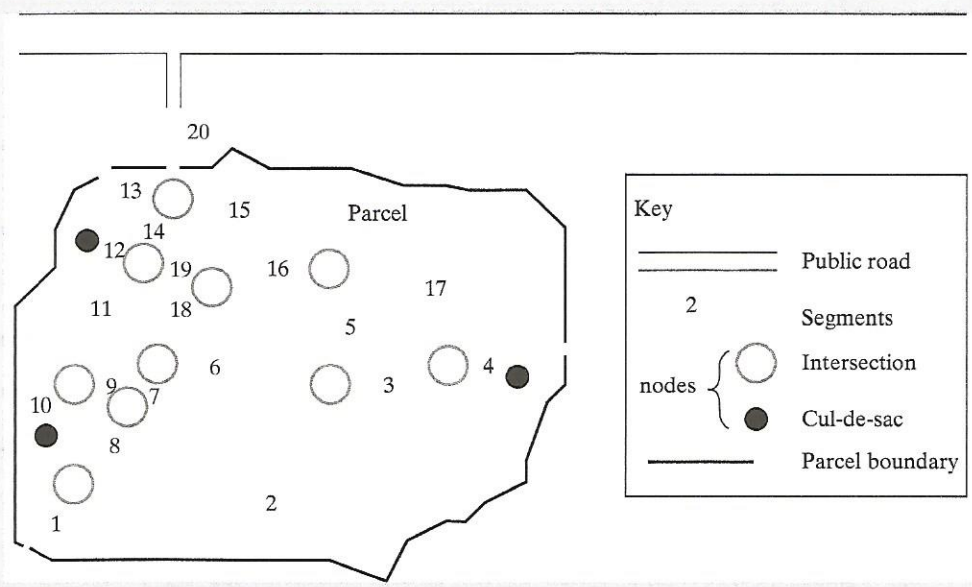


Figure 11.14b Proposed Parcel Development (Modified Proposal)

right of segment 17 is undeveloped. Finally, this index does not fully quantify the curvature of the street network.

An active field of inquiry is quantifying the extent to which various techniques for coordinating transportation and land use influence travel and land development decisions. Because the impact of such techniques may depend on local conditions, it is often appropriate to assess their impact through the collection of local data that consider activity generators in the area, localized travel patterns, and supporting policies. Table 11.4 shows how such a local study may examine the impact of four potential techniques. Since such studies require that one control for confounding factors, the interested reader should consult the literature for examples of how such factors may be addressed.

11.4.10 Freight Planning

Freight planning is similar to passenger planning in that both may be used to satisfy one or more stated policy goals. Such goals may include providing adequate facilities to meet forecasted demand, mitigating the adverse consequences of such facilities, increasing economic competitiveness, or encouraging a shift between modes. For example, an expected increase in goods movement along a north-south corridor coupled with high congestion levels on the highway facility may lead to a decision to invest in improvements in an adjacent rail line to encourage freight shipments by rail. Alternatively, the feasibility of an inland port may be assessed with respect to the proposed port's ability to increase market share for a state's seaport at the expense of ports in other states. Steps to mitigate adverse impacts of freight facilities might include the relocation of a

Table 11.4 Approaches for Quantifying the Travel Impacts of Transportation/Land-Use Coordination Techniques

Technique	*Potential Method to Determine the Technique's Impact on Travel Behavior*
Concurrency requirement	Compare transportation system performance for areas with a concurrency requirement to areas without such a requirement
Grants to encourage housing in jobs-rich areas	Compare the distances commuters travel when living in (a) areas with a mix of jobs and housing and (b) areas that are primarily residential
Priority funding areas	Compare the rate of land development in areas designated as a PFA with the rate of land development in areas not designated as a PFA
Connectivity index	Compare the number of vehicle trips entering an arterial facility from otherwise similar developments with dissimilar connectivity indices

rail yard from a residential area, reduced idling of trucks and locomotives, the construction of additional truck rest areas (to accommodate truck shipments that arrive prior to the scheduled delivery time), and noise mitigation measures—such as the construction of sound walls (to reduce truck noise) or the use of continuous welded rail to reduce train noise.

Freight planning also may be performed at both the systems level of analysis and at the project level of analysis. At the *systems level,* freight-related projects will fall within the general urban travel demand analysis process. For example, a roadway widening that will support operations at a port in an MPO area will typically be identified within the urban travel demand forecast and then be placed in the Transportation Improvement Program (TIP) for inclusion within the state highway program. At the *project level,* short-term freight projects that are of direct interest to the business community may be considered, such as railroad siding improvements, expansion of turning radii to accommodate large trucks, and traffic signal timings.

There are several possible modes for freight transportation, each with its own advantages and disadvantages. Mode categories include truck (tractor trailers, drayage trips between seaports and rail facilities, and local deliveries), rail (tank cars, containerized shipments, or boxcars), maritime (auto carriers or large vessels), and air cargo. As shown in Figure 11.15, the market share for each mode may depend on whether tonnage or value is used. For the state of Virginia, the amount of freight shipped by rail is much larger than that shipped by air if the unit of measurement is tonnage. Because commodities shipped by air have a much higher value than commodities shipped by rail, air freight has a larger market share than rail freight, as shown in Figure 11.15, if the unit of measurement is value (billions $).

The analysis underpinning freight planning considers three factors that differ somewhat from that of transportation passenger planning. First, unlike passenger freight, some commodities are shipments that are not time sensitive, thereby allowing the shipper's choice of mode for those commodities to be made solely on the basis of cost and convenience. Second, freight-movement data are generally studied at a larger geographic scale than passenger movements, with county-to-county or

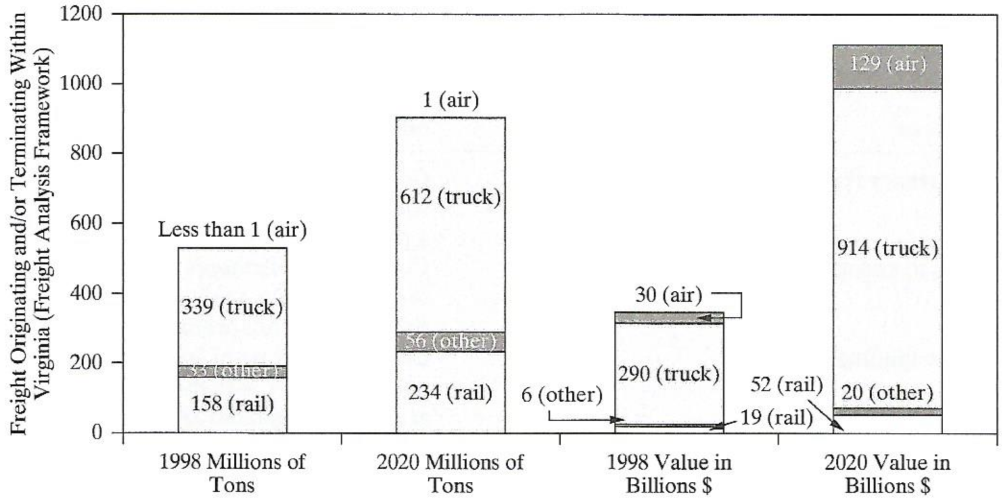


Figure 11.15 Virginia Forecasts for Freight Movements by Mode (U.S. DOT Freight Analysis Framework)

Note: Does not include freight that moves entirely through Virginia without an origin or destination therein. "Other" includes water, pipeline, and shipments that moved by an unspecified mode.
SOURCE: John S. Miller, *Expected Changes in Transportation Demand in Virginia by 2025*, Virginia Transportation Research Council, (VTRC) June 2003, VTRC 03-TAR5, Fig. 26, p. 51; http://www.virginiadot.org/vtrc/main/online_reports/pdf/03-tar5.pdf

state-to-state flows commonly analyzed. Third, whereas each passenger chooses his or her own mode and travel path, a single decision maker makes this choice for a large number of freight parcels. While an equilibrium network assignment for passenger travel may be defined as the assignment where no passenger can reduce his/her travel time (which is not necessarily the lowest system cost), a freight logistics provider may be able to consider the total system cost, where some parcels may have a longer delivery time than others.

11.5 SUMMARY

Transportation projects are selected based on a variety of factors and considerations. The transportation planning process is useful when it can assist decision makers and others in the community in selecting a course of action for improving transportation services.

The seven-step planning process is a useful guide for organizing the work necessary to develop a plan. The seven steps are (1) situation definition, (2) problem definition, (3) search for solutions, (4) analysis of performance, (5) evaluation of alternatives, (6) choice of project, and (7) specification and construction. Although the process does not produce a single answer, it assists the transportation planner or engineer in carrying out a logical procedure that will result in a solution to the problem. The process is also valuable as a means of describing the effects of each course of action and for explaining to those involved how the new transportation system will benefit the traveler and what its impacts will be on the community.

The elements of the urban transportation planning process are (1) inventory of existing travel and facilities, (2) establishment of goals and objectives, (3) generation of alternatives, (4) estimation of project costs and travel demand, (5) evaluation of alternatives, and (6) choice of project. An understanding of the elements of urban transportation planning is essential to place in perspective the analytical processes for estimating travel demand. Other elements of the transportation planning process are environmental impact statements, geographic information systems, land development policies, and freight planning.

PROBLEMS

11-1 Explain why the transportation planning process is not intended to furnish a decision or give a single result.

11-2 Describe the steps that an engineer must follow if asked to determine the need for a grade-separated railroad grade crossing that would replace an at-grade crossing of a two-lane highway with a rail line.

11-3 Describe the basic steps in the transportation planning process.

11-4 Select a current transportation problem in your community or state. Briefly describe the situation and the problem. Indicate options available and the major impacts of each option on the community.

11-5 Evaluate a proposal to increase tolls on existing roads and bridges. Describe the general planning analysis used.

11-6 Prepare a study to consider improvements to transportation between an airport and the city it serves.

11-7 What caused transportation planning to become institutionalized in urban areas, and on what does the process need to be based?

11-8 Explain the three "C"s concept in the transportation planning process, as mandated in the Federal Aid Highway Act of 1962.

11-9 Explain the difference between transportation planning and transportation programming, including differences between the key documents in each process and their respective time horizons.

11-10 Urban transportation is concerned with two separate time horizons. Briefly describe each and provide examples of the types of projects that can be categorized in each horizon.

11-11 In gathering data to support urban transportation planning, name the unit of geographic area at which data supporting an inventory of existing conditions are summarized. Note the factors that are considered in delineating these geographic units.

11-12 An existing highway-rail at-grade crossing is to be upgraded. Plans were developed in 2001; the cost estimate for that improvement was $570,000 at that time. Due to funding constraints, construction of the improvement was delayed until 2005. Using the data given in Table 11.3, estimate the construction cost in 2005 dollars.

11-13 Given the information in Problem 11-12, assume that construction was delayed until 2014. Using the compound growth rate (see Chapter 13) that can be derived from the data given in Table 11.3, estimate the construction cost in 2014 dollars.

11-14 Describe the three forms of environmental impact analysis documentation.

11-15 Identify the types of impacts and effects that might be addressed in an analysis of environmental impacts.

11-16 What is the purpose of performing inventories and surveys for each defined geographic unit or transportation analysis zone within a study area?

11-17 What are the four basic elements that make up the urban transportation forecasting process?

11-18 In the data collection phase of the urban transportation forecasting process, what type of information should the data reveal for a transportation analysis zone?

11-19 Define the following terms: (a) link, (b) node, (c) centroid, and (d) network.