

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, 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.

## 11.1 BASIC ELEMENTS OF TRANSPORTATION PLANNING

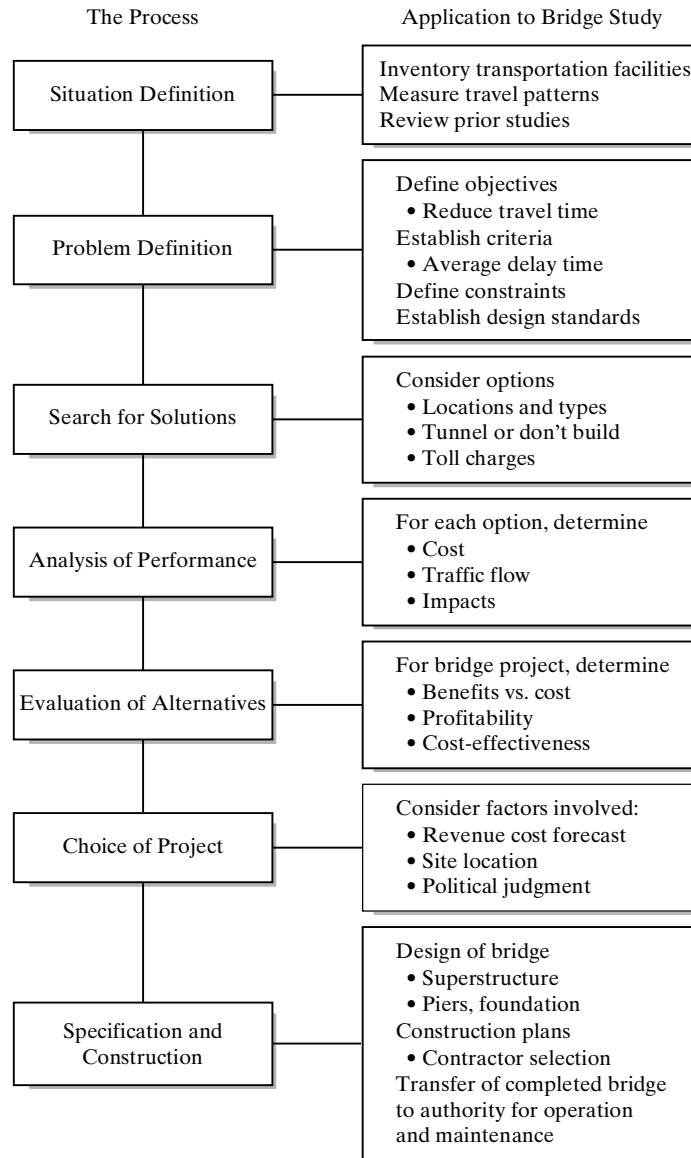
The transportation planning process comprises seven basic elements, which are inter-related and not necessarily carried out sequentially. The information acquired in one phase of the process may be helpful in some earlier or later phase, so there is a continuity of effort that should eventually result 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 and studies that may be relevant to the present situation are reviewed and



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

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 might also be held to obtain citizen input. 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) are 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, first prepare preliminary cost estimates for each location being considered. Then compute estimates of the traffic that would use the bridge, given various toll levels and bridge widths. The average trip length and average travel time for bridge users would be 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) also would be 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 positive, 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 revenue-cost forecasts and would likely 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 would be 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 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 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

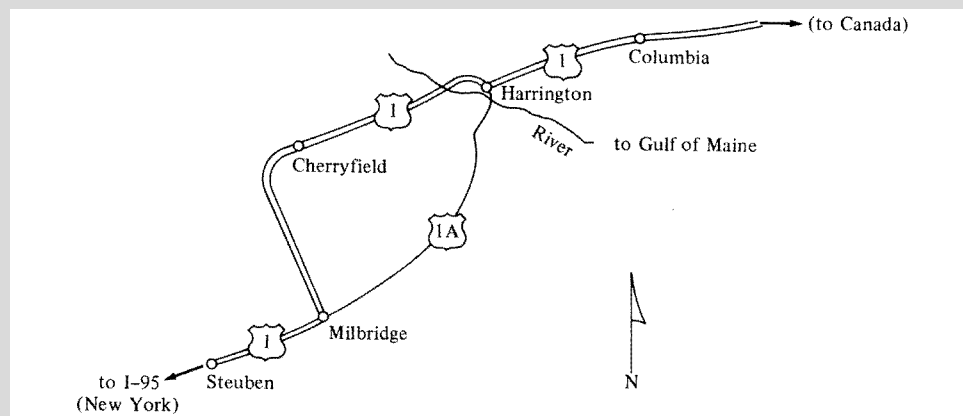


Figure 11.2 Location Map for Highways U.S. 1 and U.S. 1A

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 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.

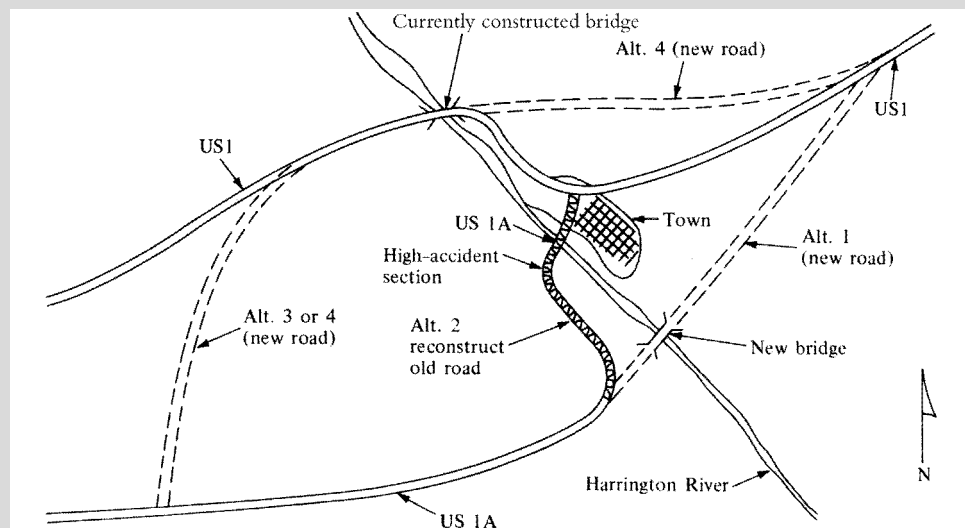


Figure 11.3 Alternative Routes for Highway Relocation

- *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 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.

**Table 11.1** Measures of Effectiveness for Rural Road

Criteria	Alternatives				
	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 (Relative to statewide average)	4	1.2	3.5	2.5	0.6
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 ( $\mu\text{g}/\text{m}^3$ 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



**Table 11.2** Ranking of Alternatives

<i>Criterion/Alternative</i>	<i>Alternatives</i>				
	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
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

**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.
- *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 accidents.
- *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.

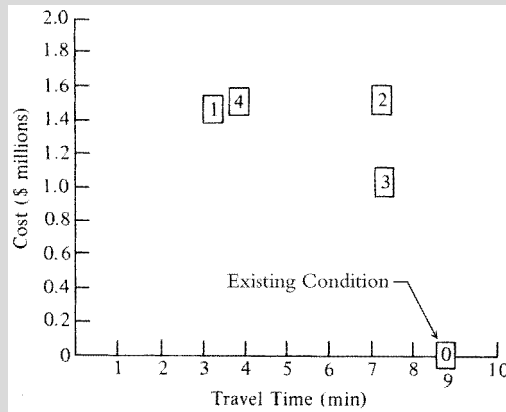


Figure 11.4 Travel Time between West Harrington and U.S. 1 versus Cost

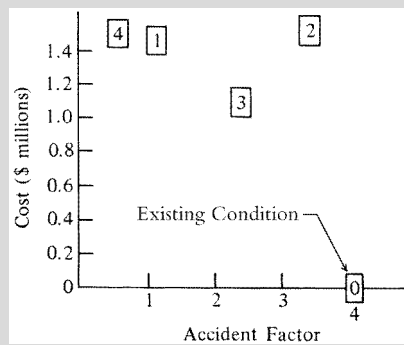


Figure 11.5 Accident Factor (relative to statewide average) versus Cost

- *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 Alternative 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