CHAPTER 4

DECISION MAKING

CONTENTS

EXHIBITS

I. INTRODUCTION

This chapter explains how to use the results of the *Highway Capacity Manual* (HCM) analyses in making decisions for planning, designing, and operating transportation facilities. It begins with the types of decisions to which the HCM usually is applied; discusses the role of measures of effectiveness (MOEs), level of service (LOS), and other performance measures; and concludes with some guidelines and examples on the presentation of results to facilitate interpretation.

II. DECISION MAKING

TYPES OF DECISIONS TO WHICH THE HCM APPLIES

Chapter 3 has described the analysis levels of operational, design, and planning. This section now turns to the types of decisions frequently associated with each of these levels. Combining service measures with performance measures allows the user to match the evaluation process to the problem at hand. However, decisions related to safety cannot be made effectively using the methodologies and performance measures in the HCM.

Operational

Operational analyses generally identify the existence and nature of a problem. Therefore, in making any decision, an analyst first considers whether a given element, facility, area, or system has a potential problem requiring study. In this case, the analyst simply decides if there is or will be a problem. This is what highway needs studies do. The prediction models of the HCM can be used even if the performance cannot be directly measured in the field. The analyst often uses the HCM as a framework to document a problem about which the agency has been alerted by the public or by other agencies.

However, operational analyses often do not end with the confirmation of a problem. They usually also entail a decision on how the problem might be remedied (i.e., through countermeasures). Typically, several alternatives for improvement are proposed, leading to the next decision. One alternative must be selected as the recommended plan. The HCM can be used to predict the change in performance measures for each alternative, to help in selecting and recommending a plan.

Examples of decisions for which the HCM can be used

Decisions that use results from the HCM include choosing among alternatives for intersection controls, for signal phasing and timing arrangements, and for minor changes to control and marking (e.g., location of parking and bus stops, reconfiguring the number and the use of lanes, frequency of bus service, and relocating or eliminating street furniture for pedestrians), as well as choosing among a combination of actions.

There also may be a need to decide on the feasibility of a proposed operational improvement. The addition of exclusive turning lanes or the extension of existing turning lanes can be considered at intersections. Another example is that a bicycle lane or a high-occupancy vehicle lane might be recommended for placement within the current right-of-way of an urban street. HCM analyses can determine if the space lost to other modes of travel (i.e., pedestrians and other vehicles) will result in an unacceptably low LOS, making the alternative unfeasible.

HCM methods are used to estimate performance measures for assessing alternative actions. Combined with other factors as desired, these then can assist decision makers in comparing alternatives and choosing the most appropriate course.

Design

Design determinations for which the HCM is used most commonly involve decisions on the number of lanes, or the amount of space, needed to operate a facility at a desired LOS. For example, if a basic freeway segment is to be designed for an LOS with a service flow rate of 2,000 passenger cars per hour per lane (pc/h/ln) and the demand flow rate is 4,500 pc/h, the number of lanes required is calculated as 2.25 (from 4,500/2,000). Based on this information only, the analyst might choose to design the segment with three lanes. However, the segment may be one of several alternative designs under consideration. Others might have better geometrics, closer to base conditions, and might result in a higher service flow rate, indicating a need for only two lanes.

This is the simplest form of design determination found in the HCM. The relationship between service flow rate and geometrics and controls is much more complex for other facility types covered—computing the number of lanes required is not a simple matter. The HCM can be used to select among alternative designs either by comparing the LOS at which each alternative would operate or by finding the attributes of the design that result in a targeted LOS.

Planning

Problem identification

HCM analyses are useful for such planning decisions as determining the need to improve a system (e.g., a highway network). This kind of analysis is similar to an operational analysis, except that it requires less detail for the inputs and uses a greater number of default values. The decision not only involves whether improvements are needed, but if so, what type and where. This is determined by testing a series of alternatives and comparing their performance measures. The measures produced by the HCM methodologies either will play a role as criteria for decision making, or they will act as interim inputs to a planning model that will generate its own performance measures. Ultimately, the HCM methods produce results that support decision making.

Alternative analyses and design determination

Planning decisions involving the HCM often relate to the feasibility of a new commercial or residential development. For example, if a shopping center is proposed for a location, the HCM analyses can be used to decide if the traffic generated by the development would result in an undesirable quality of service. This decision involves the determination of service measures, LOS, and other appropriate performance measures (e.g., v/c ratio and queue lengths). If the development is found unfeasible as proposed, due to an unacceptable impact on street or intersection operation, the HCM also can be used to assess alternative improvements to make it feasible. In this way, the HCM can be used in deciding what should be required of a new commercial or residential development as well as cost-sharing for any public improvements in conjunction with the development. For example, the developer might be required to change the location, number, or geometrics of access points based on tests made using the HCM.

Planning decisions

Planning analyses also can be performed to decide on the feasibility of a proposed policy. For example, if a city is considering a policy to provide special lanes for bicycles or high-occupancy vehicles, scenarios can be tested to allow decision makers to arrive at the most appropriate requirements for the policy.

ROLES OF PERFORMANCE, EFFECTIVENESS, AND SERVICE MEASURES AND LOS

As described in Chapter 2, operations on each facility type or element of the overall transportation system can be characterized by a set of performance measures, both qualitative and quantitative. Quantitative measures estimated using the analytical methods of this manual are termed measures of effectiveness (MOEs). For each facility type, a single MOE has been identified as the service measure that defines the operating LOS for the specific facility. (More than one MOE is used in the LOS determination for transit facilities and for two-lane highways).

LOS is only one of several ways to evaluate operational conditions

Analysis and decision making using the HCM methods almost always involves estimating or determining a service measure and the related LOS. Parts III and IV provide methods for generating performance measures in addition to the specific service measure; these can be useful inputs in decision making. In some cases, performance measures can be more important to the decision than the LOS rating. An example is the length of queue caused by oversaturation. If the analysis predicts a problem due to a queue backup into an upstream intersection, the next steps are to generate and select alternatives to resolve the problem. Another example is the volume/capacity (v/c) ratio for signalized intersections. Although delay is used to establish the LOS, the v/c ratio sometimes can indicate potential problems, even when the LOS is acceptable.

Each of the methodological chapters provides a different set of performance measures, summarized in Chapter 9. Users of this manual should become familiar with the performance measures that can be estimated using the HCM, and with how the performance measures can enhance decision making.

III. PRESENTING RESULTS TO FACILITATE INTERPRETATION

SELECTING APPROPRIATE MEASURES

Performance measures selected should be related to the problem being addressed

Several performance measures can result from HCM analyses. Determining the most appropriate measures to use for a decision depends on the particular case. However, decision-making situations generally can be divided into those involving the public (e.g., city councils or community groups) and those involving technicians (e.g., state or local engineering staff or transit planners).

The HCM is highly technical and complex. The results of the analyses can be difficult for people to interpret for decision making, unless the data are carefully organized and presented. In general, the results should be presented as simply as possible. This might include using a small set of performance measures and providing the data in an aggregate form, without losing the ability to relate to the underlying variations and factors that have generated the results.

The LOS concept was created, in part, to make the presentation of results easier to understand than if the numerical values of the MOEs and service measures were reported directly. It is easier to understand a grading scale similar to that of the traditional school report card than to deal with measures such as density and v/c ratio. Although there are limitations to their usefulness, LOS ratings remain a part of the HCM because of their acceptance by the public and elected officials. Decision makers who are not analytically oriented often prefer to have a single number or letter represent a condition. It is generally not effective to provide representatives of the public with a large set of differing measures or with a frequency distribution for a specific performance measure. If the analyst has several measures available, it is preferable to select the one that best fits the situation and keep the others in reserve until needed.

Decision makers who represent the public usually prefer measures that their constituents can understand; the public can relate to LOS grades. Unit delay (e.g., seconds per vehicle) and travel speed also are readily understood. However, v/c, density, percent time spent following, and vehicle hours of travel are not measures to which the public easily relates. When selecting the measures to present, therefore, it is important for the analyst to recognize the orientation of the decision maker and the context in which the decision will be made. In general, these measures can be differentiated as system-user or system-manager oriented. When making a presentation to technical members of a public agency, such as highway engineers and planners, it might be necessary to use more than one performance measure, especially when providing both the system-user and system-manager perspectives.

UNDERSTANDING SENSITIVITY OF MEASURES

Evaluate how results change with input assumptions

Once one or more performance measures have been selected for reporting analysis results, decision making can be improved by demonstrating how the numerical values (or the LOS letter grade) change when one or more of the assumed input values change. It can be important for the decision maker to know how an assumed increase of 15 percent in future traffic volume (compared with the standard forecast volume) will affect delay and LOS at a signalized intersection. By providing a central value along with values based on upward and downward assumptions on key input variables (especially volume), the analyst ensures that decision making is based on a full understanding of sensitivities. The *Traffic Engineering Handbook* (*1*) provides examples of tabular presentations of sensitivity results for signalized intersections.

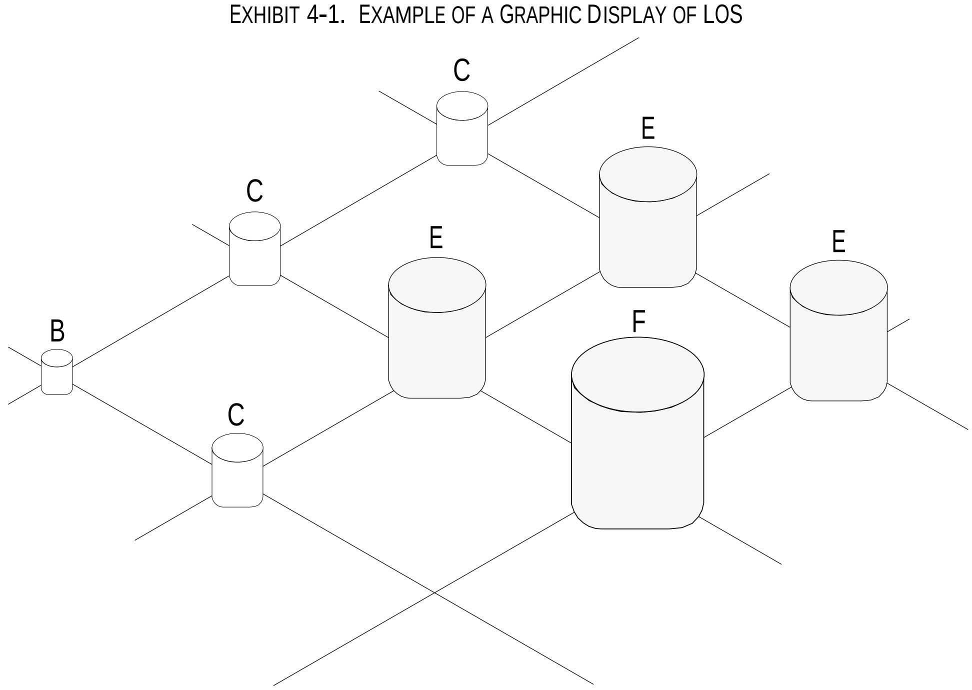
GRAPHIC REPRESENTATION OF RESULTS

Historically, data and analysis results have been presented primarily in tables. However, results sometimes are best presented as pictures and only supplemented as necessary with the underlying numbers. Graphs and charts should not be used to decorate data or to make dull data entertaining; they should be conceived and fashioned to aid in the interpretation of the meaning behind the numbers (*2*).

Present results to make them very plain (obvious) to the audience

Most of the performance measures in the HCM are quantitative, continuous, variables. LOS grades, however, are qualitative measures of performance; they do not lend themselves to graphing. When placed on a scale, LOS grades must be given an equivalent numeric value, as shown in Exhibit 4-1, which presents the LOS for a group of intersections. The letter grade is indicated, and shaded areas are defined as unacceptable LOS that do not meet the objective of LOS D. The size of the indicator at each intersection is intended to show the relative delay values for the indicated LOS.

EXHIBIT 4-1. EXAMPLE OF A GRAPHIC DISPLAY OF LOS



The issue is whether the change in value between successive grades of LOS (i.e., the interval) should all be shown as equal. For instance, is it appropriate for the LOS Grades A through F to be converted to a scale of 0 through 5? Should the numerical equivalent assigned to the difference of the thresholds between LOS A and B be the same as the difference between LOS E and F? These questions have not been addressed in the research. Furthermore, LOS F is not given an upper bound. Therefore, a graph of LOS should be considered ordinal, not interval, because the numeric differences between levels of service would not appear significant.

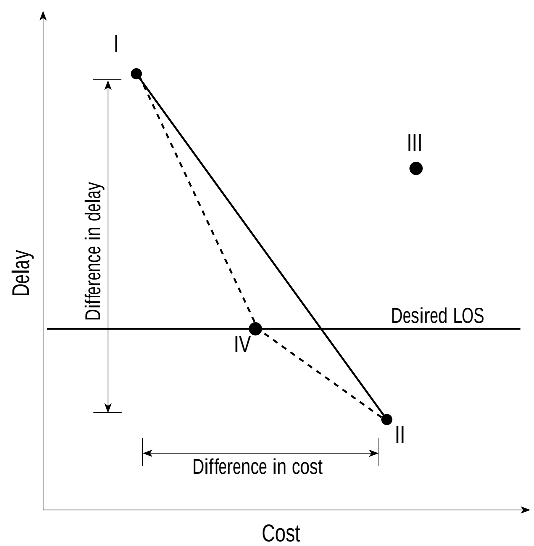
However, it is difficult to refrain from comparing the differences. A scale representing the relative values of the LOS grades would have to incorporate the judgment of the analyst and the opinions of the public or of decision makers—a difficult task. A thematic style of graphic presentation, however, avoids this issue. In Exhibit 4-2, for example, shading is used to highlight time periods and basic freeway segments that do not meet the objective LOS (in this case, D).

EXHIBIT 4-2. EXAMPLE OF A THEMATIC GRAPHIC DISPLAY OF LOS

Start Time	Segment I	Segment II	Segment III	Segment IV
5:00 p.m.	A	B	B	A
5:15 p.m.	B	B	D	A
5:30 p.m.	B	B	F	A
5:45 p.m.	B	D	F	A
6:00 p.m.	B	F	F	A
6:15 p.m.	D	F	E	A
6:30 p.m.	D	E	C	A
6:45 p.m.	B	B	B	A

Simple graphics often can facilitate decision making among available alternatives. For example, in the cost-effectiveness graph shown in Exhibit 4-3, the estimated delays resulting from alternative treatments have been plotted against their associated cost. The graph shows more clearly than a tabulation of the numbers that Alternative III both is more costly and creates higher delay than Alternative II. This eliminates Alternative III.

EXHIBIT 4-3. EXAMPLE OF A COST-EFFECTIVENESS GRAPH



Whether Alternative I or II should be chosen, however, is a matter for the decision maker's judgment. Alternative II is more expensive than Alternative I, but is predicted to deliver a significantly lower delay. A useful measure for decision makers is provided by the slope of the line between the alternatives, which shows the seconds of delay saved per dollar of cost.

For this example, assume that Alternative IV provides the minimum acceptable LOS at significantly less cost than Alternative III. The dashed lines in Exhibit 4-3 indicate the relative cost-effectiveness of moving from I to IV or IV to II. The steepest slope, I to IV, signifies a high level of cost-effectiveness. The two alternatives that meet or exceed the LOS objective are II and IV. The most appropriate alternative for selection, therefore, is Alternative IV.

The HCM provides valuable assistance in making transport management decisions in a wide range of situations. It offers the user a selection of performance measures to meet a variety of needs. The analyst should recognize that using the HCM involves a bit of art along with the science. Sound judgment is needed not only for interpreting the values produced, but also in summarizing and presenting the results.

IV. REFERENCES

1. *Traffic Engineering Handbook*. Institute of Transportation Engineering, Washington, D.C., 1992.
2. Tufte, E. R. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Connecticut, 1983.