A3A10: Committee on Highway Capacity and Quality of Service
Secretary: Richard G. Dowling, Dowling Associates

Highway Capacity and Quality of Service

WAYNE K. KITTELSON, *Kittelson & Associates, Inc.*

This paper begins with a review of the important evolutionary changes that have occurred in both methodology and philosophy since the inception of the Committee on Highway Capacity and Quality of Service (HCQS) in 1944. With the guideposts defined by this history, a vision of future directions the committee expects to undertake in the next decade is presented. Summary observations about the committee's past, present, and future conclude the paper.

INTRODUCTION

In the past 50 years, the HCQS Committee has produced three formal editions of the *Highway Capacity Manual* (HCM); the fourth edition will be published by the Transportation Research Board (TRB) in 2000. More than just describing a series of analytic procedures, these documents reflect the profession's evolution of thought over the past 50 years about the defining characteristics of our transportation system. Such changes are important to identify and reflect upon because they map a path that helps identify where the continuation of this thought process is likely to lead.

A historical review of the four editions of the HCM leads to the conclusion that in the past 50 years, evolutionary changes of significant proportions have occurred in at least three areas:

1. *Analysis scope:* The committee's primary task in the 1940s was to develop methods for estimating the hourly capacity of single points on specific highway facility types. Its focus was thus almost entirely on ensuring the sufficiency of the individual facility. This focus reflected the then-prevailing view that the transportation system is equal to the sum of its parts. That is, it was assumed that if all the pieces of the system were built to a first-class level, the system would also function at a first-class level.
2. *Level of service concept:* The committee helped to change this singular view of the transportation system when it introduced the concept of level of service in 1965. In the level-of-service (LOS) concept it was recognized that the driver's view of the transportation system is also important to consider. This view has continued to evolve toward a more global perspective. Since then, it has become important to estimate not only the level of service, but also other key operational performance measures like queue length or average speed. It has become important to be able to evaluate both undersaturated and oversaturated conditions. And it has become important to expand the analysis area from a single point to a segment, and then from a linear segment to a two-dimensional area, and then ultimately on toward a single, integrated multimodal transportation system.
3. *Analysis tools:* Technological advances have profoundly affected the way operational analyses are performed. In its earliest years, the committee operated in an

environment where the tools of the trade for both researchers and practitioners amounted to little more than pencils and paper, slide rules, and personal observation. Consequently, published analytic procedures necessarily had to rely upon simple rules of thumb and guiding principles as virtually the only means to effective practical implementation. Today, high-speed processors, personal computers, and calculators of all sizes and configurations make it possible to quickly conduct highly sophisticated mathematical analyses using such techniques as multivariate nonlinear regression, theoretically based models, fuzzy logic, and computer simulation. The committee's recent decisions to improve accuracy through methods that rely on the capabilities of these new technological tools have helped take the profession away from non-computer-based analyses.

4. *User base:* The 1950 HCM was written exclusively to address the needs of traffic engineers who were participating in planning, building, and operating specific roadway components. As the scope of the HCM expanded, so did the need to address the requirements of other transportation professionals, including planners and designers. With HCM 2000, the target audience has been expanded yet again to include consideration of ancillary disciplines (for example, air quality and noise) as well as the needs of nontechnical policy makers.

FUTURE DIRECTIONS

It is certain that evolutionary advancements and changes will continue to occur beyond the year 2000. Considering the historical evolution that has already occurred, the committee believes that there are at least two areas in which these advancements and changes can be expected over the next decade:

1. Extensions of existing work and research initiatives, and
2. Introduction of at least three new focus areas:
   a. Professional training, education, and outreach;
   b. An assessment of the value being derived from increasingly complex analytic procedures; and
   c. Development of new analysis techniques and concepts for new interest areas.

Extensions of Existing Work and Research Initiatives

Many of the new directions introduced by HCM 2000 are only first steps in a process that will take years of experience and research to mature. Some of the most significant new directions initiated with HCM 2000 include quantification and evaluation of congested (oversaturated) conditions, assessing the adequacy of the transportation system, and meeting the needs of all user groups.

Quantification and Evaluation of Congested (Oversaturated) Conditions

It is still unclear how to quantify congestion and oversaturated conditions in a way that is both meaningful and useful to the user community. What constitutes congestion in a small community may be very acceptable in a large urban area. Techniques for allowing local

communities to customize the definition of congestion to citizen expectations are just now being considered (*1–3*). Some important initial steps in helping analysts quantify congestion have been taken in HCM 2000, but significant limitations remain. For example, our current models for quantifying congestion are unable to give answers whenever the congested conditions caused by one intersection disrupt the operating characteristics of any upstream intersection. It is reasonable to expect that this type of condition will occur more and more regularly in major urban areas, and so a practical method of quantification will probably be needed in the near future.

Assessing Adequacy of Transportation System

We know that we must now begin to consider the effects of every improvement plan on the characteristics of the entire transportation system, but further research is needed to determine how best to accomplish this objective. The chapter on freeway facilities of HCM 2000 represents an important first step (*4*) but also highlights the complexity of the task. Consider, for example, a hypothetical commuter going to work on a typical weekday. She begins by leaving home on the local street that runs by her house and then she turns onto a two-lane highway. The two-lane highway becomes a multilane highway as it nears the city limits, and the commuter turns from this onto a six-lane freeway in order to get to a convenient park-and-ride facility located on the outskirts of town. She then rides a bus to a downtown stop and completes her trip by walking to her office. This commuter used many different components of the transportation system on her single trip from home to work, all of which must function as an integrated whole if the system is to provide optimal service and efficiency. What quality of service was provided by the transportation system in this case? How can the overall quality of service be assessed when all users of the transportation system are taken into account? Such questions must be answered if the capabilities of the existing transportation system are to be used to their maximum potential.

Meeting Needs of All User Groups

Over the past 50 years, we have come to realize that many more people than just the traffic engineer and highway designer have both an interest in and an impact on how the transportation system operates. These people include local and regional land use planners, air quality and noise specialists, service providers such as transit agencies and taxi companies, elected or appointed policy makers, interest groups for special users such as the visually handicapped and the elderly, and many others. With HCM 2000, the committee explicitly acknowledges the importance of providing useful guidance to ancillary disciplines and nontechnical policy makers. Unfortunately, there has not yet been enough interaction with these different user groups to ensure that the guidance they need is being addressed. It is hoped that HCM 2000 will become a new meeting point for these many different interest groups, but it will require continuing proactive work on the part of the committee to ensure that this happens. Getting in touch with the professional committees and societies representing these interest groups, inviting their representatives to participate in committee meetings, and soliciting feedback from their user groups through surveys and presentations are all effective techniques that will be used in the future to develop a better understanding of the needs of the different interest groups.

New Focus Areas

The existing work and research initiatives identified in HCM 2000 have also helped illuminate the likely next areas of focus for the committee. Following are descriptions of three of these that are expected to receive attention over the coming decade.

Professional Training, Education, and Outreach

Even at this early stage, before the publication of HCM 2000, it seems clear that training, education, and outreach will constitute critically important responsibilities for the committee during the coming decade. This need is actually a direct result of the evolution that has occurred over the past 50 years. In the late 1940s and early 1950s, there was very little difference in the educational or experience backgrounds of those conducting the research and those applying the results: both came from basic college curricula where very little was known or presented in the areas of highway capacity analysis and traffic engineering. Today, the difference can be very wide indeed. On the one hand, those conducting the research and advancing the state of the practice have graduate degrees in the field of transportation, are intimately familiar with the principles of traffic flow theory, and generally have many years of combined experience in observing traffic flow and developing mathematical models to replicate its behavior. On the other hand, those who use the analysis methods often come from educational backgrounds other than traffic engineering and do not have formal graduate-level training in the first principles of traffic flow theory. This discrepancy will become even more common as the user base broadens to include the other interest groups noted earlier. As the analytic procedures become more complex and mathematically foreign to these user groups, the computer programs that implement them could come to be seen as black boxes—that is, the opportunity for critical evaluation and interpretation of reported results is lost.

A major part of the solution to this problem is to educate and train those who rely on HCM 2000 so that they understand not only the logical underpinnings but also the practical limitations of each analysis procedure. This training can be achieved through a number of techniques, including continuing education workshops and short courses for practicing professionals, the issuance of regular interpretations and clarifications in response to user questions, and peer review of ongoing applications.

Assessment of Value from Complex Analytic Procedures

Although the importance of continuing professional education and training is acknowledged by the committee members, it nonetheless remains unclear whether the increased sophistication of current analysis techniques has had a measurable impact on improving either the quality of decisions being made or the facilities being constructed and operated. Consider the types of questions many communities will need to address in the coming decade: Should they invest in light rail or extend their arterial system and expand bus service? Does ramp metering allow better use of the transportation system and, if so, where and under what conditions? How does bus priority change the quality of service for the entire transportation system? The answers to these questions probably do not depend on ever-more-accurate estimates of control delay at a signalized intersection. They do, however, require the analysis to take into consideration a much broader view of the transportation system than has heretofore been held. In fact, initial attempts at answering these questions will likely need to take a somewhat simple view of the individual system

components in order to maintain the problem at a tractable level. Thus, it is likely that the planning-level analysis procedures contained in HCM 2000 will need to be refined and aggregated in ways that allow questions such as these to be answered.

These observations should not be read to say that there will be little or no value to improving upon the accuracy of the already complex operational methodologies contained in Part III of HCM 2000. There clearly will be, providing that the questions being addressed are both stated and answered in the context of the entire transportation system and that they recognize the changing values and expectations of the population who uses the system. For example, until the 1970s one of this profession's primary objectives was to avoid oversaturated conditions; now not only do we live with congestion in many urban areas but we are also developing methods to quantify it. A more detailed understanding of how congestion propagates and how drivers react to it will be necessary in order to allow for this quantification to be made.

New Analysis Techniques and Concepts for Emerging Interest Areas

The future can be expected to bring the need for new analysis techniques or concepts not previously required. For example, it became clear only in the later stages of planning for HCM 2000 that practitioners in the United States will soon need to consider modern roundabouts as a viable intersection form in many circumstances. Although HCM 2000 does include some initial guidance in estimating the capacity of roundabouts, it is not based on any U.S. experience and offers no guidance in estimating level of service. Numerous other examples abound. The relationship between signal warrants contained in the MUTCD and unsignalized intersection LOS analysis results in the HCM is an area of ongoing research activity. Arterial weaving considerations are becoming more important in order to maximize the efficiency with which congested urban facilities are being used, and yet this is a phenomenon about which we still know very little.

The new technologies that are continually being introduced for managing a transportation system often have the additional effect of changing the way planning and operational analyses are conducted. In this regard, new technologies affect the work of the committee in at least two ways:

1. They give the transportation professional more opportunity for control and management of the transportation system, which in turn affects the number and type of parameters that need to be considered in the analysis. Thus, for example, the use of real-time adaptive controllers introduces the need to reconsider the way in which signal cycle lengths, green splits, and offsets are calculated and applied. The result is likely to be a revision to the analysis procedures now in use, similar to what happened in the last 20 years when pretimed signal controllers started being replaced by actuated controllers.
2. They change driver behavior and expectations, which in turn have impacts that go all the way down to the foundation principles upon which the capacity and LOS estimation models are constructed. For example, the use of cameras to observe red-light running has been shown to change driver reaction to the onset of the yellow interval. To the extent such cameras are instituted in a community, then, it will be necessary to adjust the analysis assumptions upon which effective green time is calculated.

SUMMARY

The HCQS Committee has observed significant evolutionary changes in the scope of the analysis, the tools employed in the analysis, and the user base for whom the analysis procedures are being developed. Future directions beyond HCM 2000 are expected to include extensions of existing work and research initiatives and new areas of focus such as professional training, enhancement of wide-area analysis procedures, and development of new analysis techniques for emerging areas of interest. Funded research in all of these areas will be needed to ensure that transportation professionals will have the tools they need to plan, build, operate, and maintain a transportation infrastructure that maximizes the quality of life for the citizens it serves.

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