Historical Overview of the Committee on Highway Capacity and Quality of Service

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ABSTRACT

Since 1944, The Transportation Research Board's Committee on Highway Capacity and Quality of Service has been responsible for providing guidance to transportation engineers interested in estimating capacity. More recently, this Committee has also provided important guidance in methods for estimating the quality of service on transportation facilities. Future advancements in the understanding and application of capacity and quality of service techniques are likely to benefit from an awareness of the people, events, and thought processes that have shaped the *Highway Capacity Manual* as it now appears. The purpose of this paper is to provide an historical overview of the development of the *Highway Capacity Manual*, with particular emphasis on the people personalities, events, and observations that have most influenced the evolutionary process that has led to the Year 2000 *Highway Capacity Manual*.

1. INTRODUCTION

Highway capacity is a dynamic, ever-changing and evolving phenomenon. On one level, these changes reflect the evolution of the driver's environment that have occurred over the past 100 years: the number of vehicles on the road and the amount of congestion has changed significantly, as have the vehicle performance characteristics themselves and the geometric standards that we now use to design the various highway facilities. On another level, transportation engineers' awareness of the full range of variables affecting capacity has also grown in the past 50 years, as has their understanding of how these variables interact with one another in typical day-to-day situations.

Since 1944, The Transportation Research Board's Committee on Highway Capacity and Quality of Service has been responsible for providing guidance to transportation engineers interested in estimating capacity. More recently, this Committee has also provided important guidance in methods for estimating the quality of service on transportation facilities. Future advancements in the understanding and application of capacity and quality of service techniques are likely to benefit from an awareness of the people, events, and thought processes that have shaped the *Highway Capacity Manual* as it now appears. The purpose of this paper is to provide an historical overview of the development of the *Highway Capacity Manual*, with particular emphasis on the people personalities, events, and observations that have most influenced the evolutionary process that has led to the Year 2000 *Highway Capacity Manual*.

2. THE EARLY YEARS

Beginning around 1920, the results of early capacity research were beginning to be published and available for general review. Unfortunately for the practitioner, however, no single comprehensive summary of this information was available, nor was there clear consensus on the particular method to use for particular highway facility types. Only the most visionary people viewed this lack of consensus as any sort of problem, however, since congestion was rare and capacity-constrained facilities were hard to find. To the extent that capacity analyses were conducted, they tended to reflect the experiences and rules of thumb developed locally or regionally by the responsible traffic authorities.

The need for more uniformity in the methods used to estimate highway capacity became more apparent as the vision of an interstate highway system began to emerge. On April 14, 1941, President Franklin D. Roosevelt appointed a committee to outline and recommend a limited system of national highways designed to provide a basis for improved interregional transportation. The work of this committee continued for the next three years under the guidance of such persons as Thomas H. MacDonald, H.S. Fairbank, and Olav K. (O.K.) Normann.

At the time, O.K. Normann was a young engineer working under both MacDonald and Fairbank. In this role, he was responsible for doing a lot of the background work and analysis that became the technical foundation of this document. He had joined the Bureau of Public Roads in the early 1930s upon graduation from the University of Minnesota. It may have been that his experiences working under MacDonald and Fairbank became the genesis of his interest in highway capacity. In any case, he quickly displayed an ability to use his powers of observation and his keen mind to gain insights into the underlying mechanisms that defined a process or a phenomenon. As well, he was particularly adept at using the limited resources that were then available in innovative ways to advance the state-of-the-art in this area.

An example of the innovative style that became the hallmark of O.K. Normann is the technique he used to estimate the capacity of a four-lane highway. Consider that, at the time of his research, congestion on multilane highways was virtually unseen, so there was no opportunity for him to go into the field to observe a multilane facility operating at capacity. Further, outside of manual observation and stop watches, the only tool available to him was a graphic recorder. The graphic recorder used by O.K. Normann operated by recording the time separation between consecutive events. It did this by causing a mechanism holding a pen to spike whenever a telegraph key was manually depressed. The pen was placed against a continuous role of graph paper that moved at the constant speed of 36 inches per minute. Later, the physical distance between each pen spike recorded on the graph paper could be used to determine the time separation of the events.

Using only these tools plus his own powers of observation, then, how would it be possible for O.K. Normann to estimate the capacity of a multilane highway that never operates in a congested state? Normann's solution was to place two graphic recorders along the roadside, one at each end of a short road section of known length. He then used these instruments to

record the time that consecutive vehicles passed by these points, and was later able to use the graphic results to compute the speed of each vehicle. Even if the volume on the roadway was no greater than a few hundred per hour, Normann could compute the difference in speed between vehicle pairs. He observed that, as the time separation between consecutive vehicles became less, so did the difference in their respective speeds. At the point where the speed difference between consecutive vehicles became zero, Normann recorded the time spacing between the vehicles and used this to estimate the hourly capacity of the roadway. His work was extensive enough to find that capacity conditions occurred when vehicles were traveling at a speed of about 35 mph, at which point vehicles were spaced about two seconds apart. He found the time spacing between vehicles to be greater than this minimum value when they were traveling either slower or faster than 35 mph.

3. 1950 *HIGHWAY CAPACITY MANUAL*

The national vision of an interstate highway system culminated in action with the publication of the Committee's work in early 1944 in a document entitled *Interregional Highways: A Message From the President of the United States.* This document became a key impetus in the development of the interstate highway system. Simultaneous with the publication of this document, many leading transportation engineering professionals were coming to realize that better and more uniform methods of capacity estimation were needed to help guide work on all types of transportation facilities. By this time, O.K. Normann had already established himself as an authority on highway capacity, and so he was a natural candidate to lead this effort. Accordingly, the Highway Research Board established the Committee on Highway Capacity in 1944 and charged it with leading this effort. Normann was appointed as Chairman of the Committee, and it is likely that he had great influence in selecting the charter membership of the organization. The initial membership of the Committee included the following individuals:

Powell Walker (Secretary)	Nathan Cherniack
Charles French	John Gibala
Fred J. Grumm	Victor J. Hofer
Otto Jelinek	Guy Kelcey
Sidney Shapiro	Leslie Sorenson

Powell Walker had been a close associate of Normann's since coming to the Bureau of Public Roads immediately upon his graduation from the University of Florida in 1937. Normann would often use Powell as a sounding board for some of his ideas and approaches to data collection and analysis, and so it was appropriate for Powell to serve as the Committee's Secretary. It is interesting to note that, at the time of his appointment, Powell was a World War II soldier still in Europe; he actually didn't find out about his appointment until he returned to the United States in 1946.

Normann populated the Committee with people he knew and respected, and for whom he had a great deal of professional respect. This, in fact, may have been his real genius: his ability to identify other truly outstanding professionals, and to instill and maintain within them the same passion and focus that he himself brought to the field of highway capacity analysis. Such a feat was all the more amazing considering the high standards he set not only for himself but also for those with whom he worked. Normann was a strong believer in the power of observation, and he made no compromise in his continuing quest to observe first-hand traffic conditions that tested the limits of various highway facilities. Weekends, holidays, late evening hours — Normann could be found observing traffic and collecting data at all of these times. And he expected no less of those with whom he worked.

The Committee's initial objective was to produce a document that could be used by practitioners to estimate the capacity of various types of highway facilities. Since the Bureau of Public Roads was heavily invested in this effort, Normann was able to devote most of his time to the collection and analysis of relevant data. He also had access to a number of clerks who were kept busy reducing the data and tabulating the results. It was the role of the Secretary (Powell Walker) to coordinate the data collection activities and participate in both the analysis and report writing activities. Thus, Normann and Walker were largely responsible for the contents of the 1950 *Highway Capacity Manual*. The Committee membership limited their role to reviewing and approving the work and recommendations brought by these two individuals; after all, the subject was as new to them as it was to everyone else in the transportation profession. In this environment, therefore, Normann was able to have great influence on the philosophical and methodological content of the manual.

The 1950 *Highway Capacity Manual* was to be published as a document of the Highway Research Board, even though Normann, Walker, and most of the other people who contributed to it were BPR employees. Because of the substantial contributions of BPR and its employees, Thomas H. MacDonald authorized joint publication of the manuscript with the Highway Research Board only on the condition that it first be published in BPR's *Public Roads* magazine. Accordingly, an eight-part series was published in *Public Roads* which, taken together, represented the entire content of the manual. MacDonald's requirement also had a significant impact on the "look and feel" of this first *Highway Capacity Manual*: in order to avoid additional typesetting and page layout efforts, the 1950 *Highway Capacity Manual* was published with the same page layout and font types as were used in *Public Roads.*

The 1950 *Highway Capacity Manual* was a huge success. It became the standard method for highway capacity analysis in the United States, and was also translated into nine other languages for use around the world. Although it was only 147 pages in length, it defined practical methods for estimating the capacity of two-lane, three-lane, and multilane roads; signalized intersections; weaving sections; ramps; and ramp terminals. Three levels of capacity were defined:

Basic Capacity: The maximum number of passenger cars that can pass a given point on a lane or roadway during one hour under the most nearly ideal roadway and traffic conditions which can possibly be attained.

Possible Capacity: The maximum number of vehicles that can pass a given point on a lane or roadway during one hour, under the prevailing roadway and traffic conditions.

Practical Capacity: The maximum number of vehicles that can pass a given point on a roadway or in a designated lane during one hour with the traffic density being so great as to cause unreasonable delay, hazard, or restriction to the drivers' freedom to maneuver under the prevailing roadway and traffic conditions.

4. 1965 *HIGHWAY CAPACITY MANUAL*

With the publication of the 1950 *Highway Capacity Manual*, Normann believed that the work of the Highway Capacity Committee was done and that it should therefore be disbanded. Before any such action could be taken, however, it became clear that many new issues were surfacing that required additional attention. As well, there was growing interest in this field of capacity analysis by other professionals, and so instead of disbanding, the Committee actually grew, both in membership and in structure.

O.K Normann continued to chair the committee, but now in a more participatory environment. The benefit of this change was the opportunity to take advantage of the individual strengths of the many outstanding professionals who O.K. Normann appointed to the Committee. Among these were W.R. Bellis, Charles J. Keese, Donald S. Berry, Guy Kelcey, James H. Kell, Jack E. Leisch, Walter S. Rainville, Carlton C. Robinson, Alan M. Voorhees, William P. Walker, and George M. Webb.

There were no subcommittees, and so the regularly scheduled Committee meetings became the primary vehicle for active dialogue, debate, and decision-making. In this environment, all Committee members participated actively and directly in all facets of the discussion. Assistance was also sought from the outside: in 1954, for example, special forms and instructions were sent to responsible officials throughout the country with the request that they be completed and returned to the Bureau of Public Roads for analysis of signalized intersections. Detailed information was obtained during 1955 and 1956 for approximately 1,600 intersection approaches, and about two-thirds of this information was used as the basis for more detailed analysis.

Extensions to the methods contained in the 1950 *Highway Capacity Manual* came in the form of new research reports and papers prepared by an ever-widening group of professionals. Recognizing that significant advancements had been made in several areas of highway capacity even though publication of an updated Manual remained at least several years away, the Committee in 1957 sponsored the publication of Highway Research Board Bulletin 167. Of the six papers that comprised this Bulletin, all but two were authored wholly or in part by Normann or Walker. The papers dealt with such issues as the effects of mass transit, estimating the capacity of rural roads in mountainous terrain, the operation of weaving areas, and signalized intersections operating near capacity. This document became a widely used reference whose effective life extended for at least a decade beyond; it was often referred to as the $1^1/_2$ *Highway Capacity Manual.*

As is indicated by the papers he wrote, Normann continued to be very active in research activities, all the time holding to his belief that observation and empirical data were the keys to advancing the profession's understanding of highway capacity. His hands-on style of participating in these research activities became the gist of many humorous stories. One of these centered around the large and very identifiable blue Packard Normann owned during the late 1950s. He happened on one day to be overseeing a passing study in which a number of people were stationed along the roadway at regular intervals to record the initiation, duration, and completion of each passing maneuver. As a means of coordinating their activities, the observers communicated with each other via a wire telephone system that connected them. Normann was concerned that not enough passing maneuvers were being observed, and those that were observed didn't seem to be leading to a clear conclusion; even so, the field study continued for some time according to plan. Suddenly, a big blue car came into view, entering the study section at a high rate of speed. As it approached a slower vehicle, the driver initiated a passing maneuver at just the right point for data collection purposes. It was O.K. Normann in his blue Packard, and it was the first of many times the observers saw him pass through the study section that day. An associated who was on-site that day remembers the observers saying to one another time and again over the telephone, "Here comes the 'Blue Swoosh' again! ". This is one of many examples of Normann's pragmatic approach to research, and his belief that real-life data were key to developing accurate insights.

O.K. Normann was an intriguing personality in several respects. At one level, he was unquestionably the most recognized expert on highway capacity in the world — Normann presented highway capacity seminars around the world and regularly taught at Yale's Bureau of Highway Traffic. At another level, his single-minded devotion to the field of capacity and to the tasks at hand made him the prototypical absent-minded professor — colleagues would often sit with him in meetings where he became so focused on the discussion that he would light cigarette after cigarette, not realizing he already had several already burning. And at a third level, he was a driven man who got up early in the morning and worked until late at night — outside of his long workdays, Normann also built his own home, did all the mechanical work on his cars, and operated a neighborhood swimming pool, among many other things.

For both Normann and the members of the Highway Capacity Committee, the benefits associated with greater professional interest and involvement in the field of highway capacity did not come without a price: greater participation meant a wider range of opinions, and so many of the Committee's meetings involved long hours and heated discussions. Of particular significance was a growing belief by many on the Committee that there should be only one definition of capacity, and that the different conditions defined by the terms basic, possible, and practical capacities could be better described by a separate term. The concept of service quality gradually emerged from these discussions, by early 1963 the Committee voted to introduce the concept of the level of service into the next edition of the *Highway Capacity Manual*. Even after this vote, however, the Committee membership remained divided and uncertain about how this concept would actually be implemented.

The Committee was trying to move forward on several fronts simultaneously toward the publication of a new Manual, but the volunteer members found themselves quite constrained by the limits of their available time. Once again the Bureau of Public Roads

provided crucial assistance: beginning in the summer of 1963, Normann was able to have five BPR employees assigned to work full-time, under his direction, toward the development of an initial draft of the next Manual. The five assigned BPR staff members included I. Chester Jenkins, Robert E. Johnson, John B. Kemp, Howard C. Hanna, and Steiner M. Silence.

The life of the Task Force was short but intense. They first met with the Committee in the summer of 1963 in Homewood, Illinois, where BPR's Chicago office was located. The meeting was intended to give guidance and direction to the Task Force members, and extensive discussions continued on the level-of-service concept: what it actually meant and how it might be implemented. Over the next six months, the Task Force members would fly into Washington, D.C. every other week from their respective home bases and stay for two to three days for the purpose of meeting with Normann, reviewing the work they had just completed, and planning their next activities. Each member of the Task Force was assigned the responsibility of preparing one or more sections of the draft Manual. The Committee itself was also organized around the various chapters, and so there was close coordination between the "subcommittee" members responsible for each chapter and the respective Task Force member. As an example, Howard Hanna was assigned to write the section on Traffic Characteristics, and so he spent much time coordinating with the Committee members who were also involved in this activity (including Jerry Keefer, Dolf May, Matt Huber, and Carlton Robinson).

Interestingly, it was the Task Force members who actually developed and defined the six level-of-service thresholds as a way of implementing the Committee's ideas. The five basic level-of-service thresholds (excluding "F") emanated from the work that had been done on freeways. After listening to the Committee deliberations, the Task Force members realized that, for freeways at least, the Committee wanted to identify five distinctly different operating conditions:

- Level-of-service "E" was intended to replicate the notion of "possible capacity" as defined in the 1950 *Highway Capacity Manual*.

- Level-of-service "D" was intended to reflect the maximum sustainable service volume levels that were being observed in everyday situations. This was particularly focused toward Karl Moskowitz's observations on California freeways.

- Level-of-service "C" was intended to replicate the notion of "practical capacity" as defined in the 1950 *Highway Capacity Manual*.

- Level-of-service "B" was intended to represent the "practical capacity" one could expect in a rural environment

- Level-of-service "A" was included to reflect comments made by Charles Noble, who at the time was the Chief Engineer of the New Jersey Turnpike. Noble observed that his job required him to design highways that were going to be tolled, and so he wanted to provide a standard of service higher than "practical capacity."

> It was on the basis of Noble's comment that the Task Force introduced the level-of-service "A" threshold.

As an afterthought, level-of-service "F" became a catch-all: it covered the bottom part of the speed-flow curve, and therefore could reflect any operating condition that might develop in this breakdown area.

The Task Force presented this concept, along with an initial draft of the Manual, to the Committee at its next meeting, which occurred either in late December 1963 or early January 1964. The Committee accepted the work of the Task Force and adopted the method of implementing level-of-service, but not without additional debate and discussion. In fact, the discussion over level-of-service became so passionate that, at one point, Howard Hanna commented to the group: "It appears the Committee believes that, in the Beginning, God created the Heavens, the Earth, and Five Levels of Service! ". It was a humorous observation that stuck with Committee members for many years to come because it captured the intensity and single-mindedness with which the Committee members approached their work. At the conclusion of the meeting, Normann was recognized and applauded by the entire Committee for his contributions to this milestone event through the presentation of a gold watch with the inscription, "Mr. Capacity."

O.K. Normann died suddenly only a few months later in May 1964, leaving a significant void at a critical time. Carl C. Saal, who was then BPR's Deputy Director of the Office of Research and Development, was appointed to replace him as Chairman. But the task of writing, editing, and coordinating the content of the next edition of the *Highway Capacity Manual* fell largely to Arthur A. Carter, who had been serving as Secretary of the Committee under O.K. Normann and who continued in this role under Saal. It was a huge undertaking for Carter and caused him, among many other things, to spend all of Christmas Day 1964 working on a draft for Committee review. Carter is largely recognized as having made the single greatest investment of time and effort into the production of this Manual.

The Second Edition of the *Highway Capacity Manual* is known as the 1965 *Highway Capacity Manual*, but was actually published in 1966. It included several significant enhancements over the 1950 *Highway Capacity Manual*. Only a single type of capacity was defined for each type of highway. The level of service concept was introduced and defined using the "A" through "F" designation. Updated procedures were provided for the analysis of signalized intersections, weaving sections, ramps, and ramp terminals. New sections were introduced for the analysis of freeways and bus transit systems. Guidance was provided for the analysis of all-way stop-controlled intersections. The resulting document was 411 pages in length and quickly became the most widely distributed publication of the Highway Research Board. It was translated into many different languages and served as a de facto standard within many parts of the United States.

5. 1985 *HIGHWAY CAPACITY MANUAL*

Over the next several years, the Committee focused its efforts on consolidating and expanding

upon many of the new concepts that had been introduced. The Chairmanship of the Committee passed to Carlton C. Robinson until the early 1970s, and then on to Robert C. Blumenthal, who served as Chairman until 1977. During this time, significant new issues were being raised by both Committee members and outside professionals. For example, the signalized intersection analysis procedure needed to take account of the beneficial effects of the new actuated controllers that were being used with much more frequency throughout the country. Also, methods for analyzing both urban arterials and unsignalized intersections were needed, and other modes of transportation (including pedestrians and bicycles) required consideration. The level of service concept gained widespread acceptance, but the measures of effectiveness used to quantify level of service for different highway facility types were often criticized as being inappropriate and/or unreliable measures of driver satisfaction.

Several institutional changes also occurred during this time period. The Highway Research Board changed its name to the Transportation Research Board in the late 1970s in order to more accurately reflect its responsibility to all forms of transportation. The Bureau of Public Roads was replaced by the Federal Highway Administration, whose role in highway capacity research activities began to change from a leadership position to a more supporting role.

In 1977 Jim Kell was appointed Chairman of the Committee, and at about this same time a decision was made to initiate work toward the development of a third edition of the *Highway Capacity Manual*. A significant amount of new research was undertaken from this point on through the mid-1980s, funded largely by the FHWA and the National Cooperative Highway Research Program (NCHRP). Because the number of issues to be addressed had expanded so much, the Committee adopted a new name—the Committee on Highway Capacity and Quality of Service—to more accurately reflect is expanded interest area. It also adopted a new structure involving the use of subcommittees, each of which was chaired by a full Committee member, as a means of efficiently addressing the expanding list of topics that were to be included in the new Manual.

It was within this same time frame that electronic calculators and early versions of personal computers were just becoming available. This emerging technology left the Committee in a predicament: on the one hand, the availability of such technology held the promise of significantly improving the accuracy of the analysis methods since they allowed for iterative and more computationally intensive techniques. On the other hand, this technology was not yet widely available, and many practicing engineers were still relying on slide rules and/or calculators with very limited capabilities. Recognizing that existing HCM users had widely varying levels of access to this emerging technology, the Committee elected to require that all analysis methods described in the HCM had to be capable of being implemented using paper-and-pencil techniques.

Significant advancements had been made in highway capacity analysis techniques by 1980, yet the completion of the third edition of the *Highway Capacity Manual* was still a number of years away. The Committee therefore produced *Transportation Research Circular 212,* which contained interim materials for highway capacity analysis that had not yet been approved for inclusion in the next *Highway Capacity Manual*, but which were believed to be significantly better than the analysis procedures described in the 1965

HCM. TRC 212, as it came to be known, proved to have more of a life than the Committee had originally envisioned. Many practitioners came to view it as the next edition of the *Highway Capacity Manual*, and a number of agencies continue to rely upon it even today. This fact notwithstanding, the Committee applied the feedback it gained from users of TRC 212 to modify, replace, and add to the described methods.

In 1983 Carlton C. Robinson again assumed Chairmanship of the Committee, this time to shepherd the Committee through the process of producing the next edition of the *Highway Capacity Manual*. Through his leadership, inconsistencies and differences between chapter methodologies were identified and resolved, and the third edition of the *Highway Capacity Manual* was published in January 1985. Also referred to as the *1985 Highway Capacity Manual* or *TRB Special Report 209*, the document was 503 pages in length and was published in a three-ring binder format so that individual chapters could be updated on a more regular basis. Once again, this edition of the *Highway Capacity Manual* became the most widely distributed of all TRB publications, and it was translated into a number of different languages for use internationally.

The switch to a three-ring binder format reflected the quickening pace of change that was occurring in the fields of highway capacity and quality of service estimation. Contributions from individual research efforts to large-scale publicly funded programs were being identified on a regular basis. Even at the time of publication for the *1985 Highway Capacity Manual*, for example, a major research effort was ongoing to improve the analysis methodology for multilane rural highways. It therefore became apparent to the Committee membership that future updates and new editions of the HCM would have to be provided at time intervals substantially less than the 20 years that separated the publication of the second and third editions.

6. 1994 AND 1997 UPDATES

Adolf D. May was appointed to the Chairmanship of the Committee in 1989, and almost immediately began the planning for the next edition of the *Highway Capacity Manual*. First, the Committee membership developed a prioritized listing of research activities needing to be completed prior to the publication of the next edition of the *Highway Capacity Manual*. This research program was published in 1991 as *Transportation Research Circular 371*, which in turn became the primary instrument for approaching potential funding partners. Working closely with TRB, AASHTO, FHWA, FTA, NCHRP and TCRP, a collaborative pooled-funds approach was identified for producing a new edition of the *Highway Capacity Manual* by the Year 2000, and new research activities were initiated.

Taking advantage of the three-ring binder format of the *1985 Highway Capacity Manual*, the Committee produced and delivered an update to seven of the 14 chapters in 1994. The updated chapters included those dealing with definitions and concepts, traffic characteristics, basic freeway segments, ramps and ramp junctions, multilane highways, signalized intersections, and unsignalized intersections. The analysis methods described in these chapters were telling in their sophistication and complexity: beginning with this

update, the Committee had determined that it would no longer sacrifice the accuracy of the result for the simplicity of the analysis procedure. With the ready availability of powerful personal computers, the Committee decided to include within the HCM analysis procedures and techniques that could be practically implemented only through the use of specialized computer software.

Another of May's very significant contributions was his early recognition of the value of international collaboration. Advancements in the understanding of highway capacity and quality of service were not limited to the efforts of U.S. researchers, but were occurring around the world. In fact, the operational characteristics of several highway facility types (unsignalized intersections are a notable example) were clearly better understood outside of the United States, where different research priorities had resulted in different investment strategies. To take advantage of these international perspectives, May prevailed upon TRB to increase the size of the Committee, allowing up to seven international representatives at any given time. He also initiated the Committee's sponsorship of International Symposia on Highway Capacity, which were held every three to four years in conjunction with the Committee's midsummer meeting. Each of these symposia attracted 150–300 professionals representing more than 20 countries, and included technical paper sessions and country reports to facilitate interaction and communication. The result was and continues to be substantially improved analysis procedures and Committee awareness of international research findings and initiatives.

John D. Zegeer became the sixth Chairman of the Committee on Highway Capacity and Quality of Service in 1995. Upon his appointment, the 1994 update had just been delivered while major research efforts were beginning, underway, or nearing completion for a number of different facility types. Even though the publication date for the fourth edition of the *Highway Capacity Manual* was only four years away, the Committee believed it would be appropriate to provide users with another update to the third edition in 1997. At least two factors contributed to this decision:

1) Significant advancements in highway capacity and quality of service analysis techniques were anticipated to be available prior to 1997, particularly for facility types of special interest to many practitioners (including basic freeway segments, signalized intersections, unsignalized intersections, and urban arterials).

2) Due to federal legislation, it was expected that the Committee would need to provide guidance to practitioners in conducting a metric analysis of highway capacity and quality of service for any type of facility prior to the Year 2000. Any chapter updates that might be ready by 1997 could therefore be easily packaged with a Metric Analysis Reference Guide that would need to be published and distributed in any case.

Based on this, an additional update was published in 1998, but is nonetheless referred to as the 1997 HCM update. This update consisted of seven new chapters, including those dealing with the introduction, traffic characteristics, basic freeway sections, weaving areas, signalized intersections, unsignalized intersections, and urban arterials.

7. HCM2000

The HCM2000 represents a significant advancement in the evolution of the *Highway Capacity Manual*. Written for a wider range of users, it is a four-part document consisting of 33 chapters and over 1,100 pages, and is published in both metric and U.S. Customary units. While it continues to provide state-of-the-art analysis techniques for individual highway facility components, it is also the first edition of the manual to give serious consideration to methods for evaluating the operational characteristics of the overall transportation system. It acknowledges the role of simulation and other modeling techniques, and is written for a broad group of interests ranging from policymakers to engineering specialists. The format of the document is also quite different from previous editions, reflecting the changing manner in which information is distributed and applied. The Manual has been produced in the traditional hardcopy format, but also comes in a CD-ROM format with multimedia components that enhance its usability and effectiveness (for example, hypertext links, video and audio clips, and animated tutorials and example problems). Finally, the Manual is supported by software developed by third-party vendors who are intent upon offering a faithful implementation of the analysis procedures.

8. SUMMARY

Even though it is now over 50 years old, the Committee on Highway Capacity and Quality of Service continues to serve the needs that first caused it to be created. In a real sense, the 2000 *Highway Capacity Manual* is a reflection of the individual and collective contributions of the many individuals who have guided and participated in the Committee's activities during this time. This historical overview provided in this paper is intended to give perspective to those who will guide the Committee and the research it oversees in the years to come.

It is certain that evolutionary advancements and changes will continue to occur beyond the Year 2000. Future efforts will need to address more complex problems such as the analysis of oversaturated facilities and networks. Transportation system analysis techniques will need to be developed and refined. Above all, education, training, and outreach will constitute critically important responsibilities for the Committee during the coming decade in order to assure that the sophisticated analysis techniques now available to all practitioners are effectively understood, applied, and interpreted.