100 YEARS TRB MOVING IDEAS: ADVANCING SOCIETY

CENTENNIAL PAPERS

Standing Committee on Transit Capacity and Quality of Service (AP015)
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Transit Capacity and Quality of Service

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INTRODUCTION

Transit quality of service, reflecting passengers' perceptions of how well transit service is provided, is a vital consideration when planning and operating transit service. Excellent service quality retains existing passengers and attracts new ones, and contributes to a perception of a well-managed organization among decision-makers and the general public. Quality of service addresses the *availability* of transit service—where, when, and how often service is provided—including passengers' ability to access transit service as well as information on how to make a trip by transit. Quality of service also considers the *comfort and convenience* of transit service, encompassing such factors as reliability, travel time, crowding, safety, and security. Transit agencies must balance competing service quality objectives, for example coverage vs. frequency, when allocating their finite resources within their service area.

Transit capacity represents how many persons can be consistently and reliably served within a given period of time. Larger urban areas can experience capacity problems that can manifest themselves in circumstances such as bus congestion along a street or at a transit center, an inability to add additional trains to a line, constraints on scheduling ferry routes converging on a single landing, or crowded station platforms. Demand-responsive service providers experience capacity issues as too many people wanting to travel at the same time, leading to scheduling passenger trips at less-desirable times or even service denials. Many of the same factors that influence transit capacity also influence transit speed and reliability, which a transit agency of any size should be concerned with, as speed and reliability affect both quality of service and the cost of providing transit service at a given frequency.

The scope of the TRB Committee on Transit Capacity and Quality of Service cuts across all urban public transportation modes, and also across the areas of transit planning, operations, design, and management. The committee is concerned with relationships among physical and non-physical factors affecting transit capacity and quality of service; techniques for measuring, reporting, and applying capacity and quality of service; and acceptable standards of service based on measurable characteristics. The committee supports the practitioner community in learning about and applying capacity and quality of service concepts and methods in its role of providing stewardship of TRB's *Transit Capacity and Quality of Service Manual* (TCQSM, Kittelson & Associates, Inc. et al. 2013) through workshops, webinars, TRB Annual Meeting sessions, and identifying research needs.

COMMITTEE HISTORY

The committee's origins date back to 1998, when a Task Force on Transit Capacity and Quality of Service was formed while the first edition of the TCQSM (Kittelson & Associates, Inc. et al. 1999) was being prepared. The TCQSM was envisioned as the transit counterpart to the widely used *Highway Capacity Manual* (HCM), serving as a consolidated, authoritative source of transit capacity and quality of service concepts, definitions, methods, and applications for planning, designing, and operating transit services and facilities. The task force, and eventual committee, was envisioned to follow the successful model used since 1944 by the TRB Highway Capacity and Quality of Service Committee in assembling a highly knowledgeable committee of practitioners, researchers, and educators to shepherd the development and evolution of the HCM through reviewing draft chapters, sponsoring user outreach and training, and developing and finding sponsors for research problem statements to ensure HCM methods continued to represent the state of the practice.

The task force became a full standing committee in 2003, the same year when the second edition of the TCQSM was published (Kittelson & Associates, Inc. et al. 2003). One of the committee's key roles since that time has been to develop and identify sponsors for research problem statements in areas within the committee's scope. Although one aim of this research has always been to enhance a portion of the TCQSM, the committee has always felt as well that the research should provide an immediately useful, stand-alone product. Transit Cooperative Research Program (TCRP) reports that have resulted from committee-sponsored research problem statements include:

- *TCRP Synthesis 83: Bus and Rail Preferential Treatments in Mixed Traffic*
- *TCRP Synthesis 139: Transit Service Delivery Evaluation Standards*
- *TCRP Report 152: Guidelines for Ferry Transportation Services*
- *TCRP Report 165: TCQSM 3rd Edition*
- *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*
- *Minutes Matter: A Guide to Bus Transit Service Reliability* (TCRP Project A-42, in publication)

The committee has also been active in sponsoring workshops at TRB Annual Meetings, including workshops held in 2000, 2005, and 2014 to introduce the TCQSM 1st, 2nd, and 3rd Editions, respectively. The committee also sponsored a workshop in 2010 to present examples of how the first two editions of the TCQSM had been applied and to solicit participant input to be used in shaping the 3rd Edition. Most recently, the committee co-sponsored a workshop in 2019 on planning and implementing commuter ferry service.

In 2016, again following the successful model used by the Highway Capacity Committee, the committee developed a research program for projects to address gaps in knowledge that had been identified during the production of the TCQSM 3rd Edition, with the intent of closing those gaps in time for a 4th Edition that would be published approximately 10 years after the 3rd Edition. The committee updates the program each year, removing projects that have received funding, updating other problem statements based on funding program feedback, and identifying potential sponsors and supporters for projects for the upcoming year.

IMPORTANCE OF THE TCQSM

The TCQSM has achieved the original vision of becoming an authoritative reference. Some of the transportation documents that refer readers to the TCQSM include:

- *Highway Capacity Manual,* 6th Edition (TRB 2016), where the TCQSM is presented as a companion document on a par with the AASHTO *Policy on Geometric Design of Highways and Streets* (Green Book) and FHWA's *Manual on Uniform Traffic Control Devices* (MUTCD);

- AASHTO *Guide for Geometric Design of Transit Facilities on Highways and Streets* (2014), where the TCQSM is used a source for capacity and quality of service information in nearly every chapter;
- NACTO *Transit Street Design Guide* (2016), which describes the TCQSM as "a foundational tool for understanding transit passenger service needs and outcomes"; and
- The World Bank's *Public Transport Capacity Analysis Procedures for Developing Cities* (Reilly and Levinson 2011), which presents recommended methods for planning and analyzing transit systems in developing countries by adapting TCQSM methods.

The Federal Transit Administration (FTA) also applies the TCQSM and refers transit agencies to it. For example, a basis for the FTA's core capacity methodology for the Section 5309 grant program is "the industry-recognized *Transit Capacity and Quality of Service Manual*" (FTA 2015). The FTA's *Project and Construction Management Guidelines* refer transit agencies to the TCQSM as "a good reference for a Project Sponsor to provide [a transit capacity] analysis for its proposed project" (Shadan et al. 2016).

Two major roles of the TCQSM are as a resource for university-level public transportation education and training, and as a source of transit concepts and information for new transit agency employees who have joined from another industry. Universities that incorporate TCQSM into their coursework include Georgia Tech, Massachusetts Institute of Technology, Portland State University, University of Arizona, University of Idaho, Utah State University (Watkins, La Mondia, and Brakewood 2015); Queensland University of Technology, Australia (Bunker 2016); and Monash University, Australia. The TCQSM is one of the key sources for a standardized course on public transportation made available by the Southeastern Transportation Research Innovation, Development, and Education Center (STRIDE 2016).

A significant amount of TCQSM content has been developed through the TCRP program. As a result, the TCQSM serves as an important tool for disseminating TCRP research results to practitioners long after the original research has been completed. TCRP projects have provided foundational research for TCQSM methods on bus and rail transit capacity and quality of service, have formed the basis of individual sections, and have provided sources of information throughout the manual. In all, 45 TCRP projects have contributed in some way to the manual.

The long-term value of the manual is demonstrated by its consistent appearance on TCRP's annual lists of most-downloaded publications, even years after publication. Since its publication in 2013, the TCQSM 3rd Edition has been accessed over 10,000 times, through downloads from TCRP dissemination sites, sales of the print version, and views in OpenBook sessions. Although detailed statistics are unavailable, the print version of the TCQSM 2nd Edition was consistently one of the most-requested TCRP reports during its 10-year life.

However, despite its demonstrated popularity, the manual will only remain relevant to users if its information is kept current by reflecting new industry trends and new technologies that have appeared since the previous edition was published, and changes in community expectations of transit with time. This is an area where the Transit Capacity and Quality of Service Committee provides a valuable contribution.

CURRENT ISSUES AND RESEARCH NEEDS

Connected and Autonomous Vehicles

The public transportation industry is no stranger to automation, with 65 fully automated metro lines in operation in 42 cities worldwide (UITP Observatory of Automated Metros

2019). Although no one can say yet with confidence how quickly fully automated technology will be adopted by roadway-based travel modes, how connectivity will be provided and maintained over time, or how fully automated vehicles will be allowed or required to operate, there is no questioning the amount of resources currently being invested in developing the required technologies and infrastructure.

From a transit capacity and quality of service viewpoint, driverless buses offer transit providers the potential to offer more service for the same operating budget and may facilitate first-/last-mile connections in areas unable to support fixed-route transit service. At the same time, these vehicles may have different operating characteristics (e.g., time required to dock at a stop) than human-driven buses; these characteristics can ultimately affect capacity (e.g., average time a bus occupies a stop) and quality of service (e.g., trip travel time). Passengers' perceptions of personal security while using automated shared-occupancy vehicles (public transit or otherwise), particularly when alone or with only a few passengers aboard, may become an important on-board quality of service factor.

The adoption of automated technology by other travel modes will also affect transit capacity and quality of service. For example, if driverless private vehicles result in more vehicular travel (e.g., transport of persons who currently have no driver's license, vehicle repositioning without passengers), the speed and reliability of transit vehicles operating in mixed traffic will suffer.

The Transit Capacity and Quality of Service Committee has started to investigate how TCQSM content will need to change to reflect the adoption of automated and connected vehicle technology by both public transit and private vehicles. The committee's initial work indicates that nearly every section of the manual will need to be updated in some way.

Passenger Value of Time

It is well understood that transit passengers perceive certain parts of their overall trip as being more onerous than others. For example, passengers perceive walking and waiting time as being approximately twice as long as a similar amount of in-vehicle time (Pratt and Evans 2004), while unexpected wait time can be perceived as 3–5 times as long as in-vehicle time (Vincent 2008), and travel in a crowded transit vehicle is more burdensome than travel in a less-crowded vehicle (Concas and Kolpakov 2009).

When customers' time can be valued across a wide variety of anticipated conditions, existing quality-of-service performance measures that have a temporal component can be monetized. Monetization provides a consistent quantitative measure of the quality of service provided to the transit customer, particularly as traveling conditions vary, and allows operating and infrastructure changes to be prioritized in terms of the perceived travel-time benefit.

Monetization also enables decision makers to benchmark and compare the quality of service their agencies and systems provide with greater rigor and certainty. It enables decision makers to test alternative transit capacity and quality of service options with higher certainty, in line with the level of economic evaluation of other transportation projects. Finally, monetization allows transit projects to compete on a more-equal footing for scare transportation dollars, by allowing more of a transit project's benefits to be quantified. A recent survey (De Gruyter and Currie 2018) has identified that monetizing the value of transit amenities is a standard part of the project appraisal process in many Australasian cities, as well as in London and Oslo, but appears to be little used in North America.

The TCQSM 3rd Edition introduced a section describing the state of knowledge of transit passenger values of time. Much of the information was derived from research outside the United States—particularly from the United Kingdom—and knowledge about the value passengers placed on transit amenities was generally lacking. However, the manual

acknowledged the great potential for applying value of time as a means of quantifying multiple aspects of quality of service—for example, travel speed, reliability, passenger loading, and provision of amenities—in a single performance measure. To that end, the Transit Capacity and Quality of Service Committee has developed a research problem statement to expand North American knowledge on passenger values of time and to develop guidance on how transit and metropolitan planning agencies can incorporate this information into decision-making when evaluating project alternatives and developing business cases for projects.

Use of Big Data to Measure Quality of Service

To date, the TCQSM has presented performance measures that assess the quality of service perceived by an *average* transit passenger. However, improvements in data gathering, storage, and computational technology are now making it possible to assess the quality of service actually provided to *individual* passengers. In addition to allowing passenger experiences to be better quantified, this technology also offers transit agencies the potential to more quickly identify and address service quality problems when they occur.

Papers presented at the 2019 TRB Annual Meeting in a session sponsored by the Transit Capacity and Quality of Service Committee (Graves et al. 2019, Halvorsen et al. 2019) highlighted how New York City Transit (NYCT) is merging data from its fare collection, train operation, and bus operation systems, along with information from trip-planning models, to assess how long each individual bus or subway passenger's trip actually took, compared to how long it should have taken if service had operated as planned. NYCT can use the passenger-level data to weight the impact of service delays by the number of passengers affected, allowing decision makers to prioritize operational changes on the basis of the number of passengers affected.

The TCQSM 1st Edition, which introduced the quality-of-service framework, recognized that transit agencies had access to different levels of technology, but that certain technology offered the potential for improving the measurement of aspects of quality of service. For example, in 1999, the use of geographic information systems (GIS) was not yet widespread, but GIS offered the potential for more-refined assessments of transit service coverage than was previously possible. As a result, the TCQSM offered alternative methods of assessing quality of service: one for transit agencies with access to GIS software and data, and another for transit agencies lacking these tools. A similar approach could be taken in the next edition of the TCQSM with regard to applying big data in measuring quality of service.

Implementing and Operating Commuter Ferry Service

A workshop at the 2019 TRB Annual Meeting, co-sponsored by the TRB Ferry Transportation and Transit Capacity and Quality of Service Committees, highlighted the recent expansion of commuter ferry systems around the United States. NYC Ferry has opened five new routes in the last two years, with further expansion under development (New York City Economic Development Corporation 2019), while voters in the San Francisco Bay Area approved a regional transportation funding measure in 2018 that includes $300 million in capital projects and $35 million in annual operating funding support to expand ferry service on San Francisco Bay (Metropolitan Transportation Commission 2019).

Despite this interest in ferries as a transportation option, national guidance is lacking on implementing and operating new ferry services. In addition, the TCQSM's ferry capacity chapter does not have the same level of grounding in research that the manual's bus, rail, and facility capacity chapters do. To address these needs, the two TRB committees have developed a research problem statement to develop this guidance and knowledge.

Forecasting Bus Speeds in Mixed Traffic

Although about 98% of bus revenue miles are operated in mixed traffic (APTA 2015), most research has focused on exclusive bus lanes. Accurately estimating bus speed is important for planning service on new or modified bus routes, because bus speed directly influences the time required to travel a route and thus the number of buses (and cost) required to serve a route at a particular headway. Estimating bus speed is also important for estimating the benefit to riders of implementing a transit-supportive roadway treatment such as a bus lane, and for estimating the change in ridership that may result on a route as a result of improved bus speeds. When potential projects to improve bus speeds compete against roadway improvement projects for other modes, it is important to be able to accurately and efficiently estimate the project's benefit.

Data from two cities reported in NACTO's *Transit Street Design Guide* (2016) indicate that traffic signal delays account for 23% of overall bus travel time, and delays due to other road users account for an additional increment of travel time; however, the TCQSM's bus speed estimation method does not directly model these effects. As a result, research is needed to improve the TCQSM's method for estimating bus speeds in mixed traffic to provide greater confidence in the validity of the method's results. In addition, guidance on best practice and techniques for estimating bus speeds for different applications would be useful to a variety of transit, transportation, and planning professionals.

The Transit Capacity and Quality of Service Committee has developed a research problem statement to address this need and is currently working to merge this statement with one developed by the Highway Capacity and Quality of Service Committee to develop better methods for estimating vehicle speeds and reliability on urban streets.

LOOKING TO THE FUTURE

The Transit Capacity and Quality of Service Committee has a unique role in the Public Transportation Group in that it cuts across modes (bus, paratransit, rail, and ferry) and functions (planning, operations, design, and management) and therefore provides a holistic view of moving large numbers of people within urban areas and providing effective transit coverage in suburban and rural areas. It is also one of the few TRB committees that, in addition to its normal committee responsibilities, is responsible for supporting a living document by developing research problem statements, providing post-publication user support, educating potential and current users, and reviewing the content of new editions as they are developed.

The Committee looks forward to continuing to identify and advocate for research needs that address issues of capacity and transit quality of service, for all transit modes and areas of service. These research needs will evolve as demographic shifts and technology factors continue to impact the overall transportation industry. The Committee will also continue to work toward maximizing the usage of the TCQSM as a premier educational tool for university programs and professionals alike. Future activities will focus on these areas, and the Committee looks forward to working with other TRB committees to sponsor Annual Meeting workshops and sessions and to identify and refine research topics.

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