

CHAPTER 1 USER'S GUIDE

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1. INTRODUCTION

The *Transit Capacity and Quality of Service Manual* (TCQSM, 1) was initially published in 1999 as a comprehensive reference resource for public transit practitioners and policy makers. It assembled for the first time in one place a set of methods for evaluating the capacity of bus and rail transit services and facilities, and introduced a framework for evaluating the quality of transit service from the passenger point of view.

Whereas the 1st Edition was primarily a synthesis document, with the quality of service framework its main contribution, the 2nd Edition (2) sought to fill gaps in knowledge. This edition introduced material on ferry transit capacity, expanded coverage of demand-responsive transit (DRT) and Americans with Disabilities Act (ADA) issues, and added information about transit preferential treatments and park-and-ride access to transit. It also made changes to the quality of service framework based on user testing and additional research, including adding pedestrian environment considerations to the assessment of transit service coverage and adding a new measure of transit reliability, headway adherence. The 2nd Edition, published in late 2003 as *TCRP Report 100*, went on to become TCRP's best-selling report.

This 3rd Edition of the TCQSM incorporates new research on transit capacity and quality of service topics published since the 2nd Edition was developed, including original research conducted as part of the production contract for the manual. This edition is also significantly reorganized in response to user feedback. The "What's New" section of this chapter describes the major changes from the 2nd Edition.

The TCQSM is a reference work that provides current research-based guidance on the following topics:

- **Evaluating quality of service**, reflecting how passengers perceive the quality of the transit service offered and provided, while also considering the transit provider's needs and objectives.
- **Measuring transit capacity, speed, and reliability**, and the factors that influence them—these are important operational concepts that ultimately affect the cost of providing transit service and the demand to use the service.
- **Sizing elements of transit stops and stations**—for example, platform areas, fare collection elements, and passenger and vehicle circulation elements.
- **Guidance on ways to positively influence all of the above**, including their potential effects on operations, operating costs, and existing ridership demand.

HOW TO USE THE MANUAL

The TCQSM has a relatively broad scope and is written to satisfy the information needs of a variety of audiences. As a result, it contains a lot of information and its size may be intimidating to first-time readers. However, once familiar with basic capacity and quality of service concepts, most users will only need to use individual chapters, or portions of chapters, for any given application. This section describes how the manual is organized and how to quickly find information.

Organization of the Manual

The TCQSM 3rd Edition consists of twelve chapters, divided into four main topic areas: (a) introduction, (b) concepts, (c) methods, and (d) reference material, as illustrated in Exhibit 1-1.

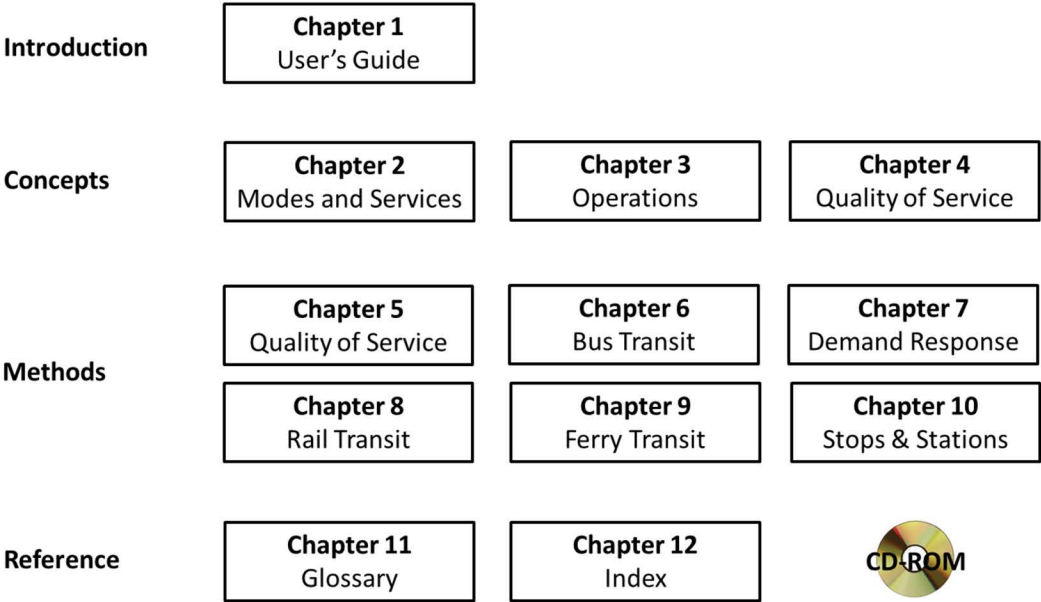
Introduction Chapter

This introduction chapter (Chapter 1) provides a guide to the rest of the manual:

- Section 2 presents the manual’s purpose, scope, and intended users.
- Section 3 describes the contents of each chapter.
- Section 4 highlights the changes made since the 2nd Edition.
- Section 5 describes companion documents to the TCQSM that may need to be consulted when performing certain types of analyses.

Organization of Chapter 1.

Exhibit 1-1
TCQSM Chapter Organization



Concepts Chapters

The three concepts chapters present concepts, define important terms, and provide illustrations of the extent to which various factors inside and outside a transit agency’s control influence transit capacity, speed, reliability, and quality of service.

- *Chapter 2, Mode and Service Concepts*, introduces the major transit modes addressed by the TCQSM—bus transit, DRT, rail transit, and ferry transit—along with their submodes (e.g., light rail, heavy rail, commuter rail) and the types of vehicles used for service. The chapter also describes route and network service patterns for fixed-route and DRT services. This chapter provides a useful introduction to public transit to those who have not worked in the area or studied it before.
- *Chapter 3, Operations Concepts*, is all about transit speed, capacity, and reliability and how various factors in and out of a transit agency’s control influence them. The chapter defines speed, capacity, and reliability; describes how passenger

Fixed-route transit service operates on a defined route according to a defined schedule. Demand-response transit has a flexible route, schedule, or both.

demand patterns, dwell time, operating environment (right-of-way type), and stop and station characteristics affect them; and presents a series of graphs illustrating the relative impacts of various factors on transit capacity and speed. Ideally, readers will be familiar with this chapter's contents prior to using any of the methods presented in the mode- and facility-specific capacity chapters (Chapters 6–10).

- *Chapter 4, Quality of Service Concepts*, describes the many roles transit plays within a community and the different perspectives that different stakeholders bring when considering the performance of transit service. *Quality of service focuses on the passenger perspective*. This chapter presents the important quality of service factors that have been identified by research, introduces the quality of service framework that is the focus of Chapter 5, and describes the relationship of changes in quality of service to both ridership and service costs. Readers will ideally be familiar with this chapter prior to applying Chapter 5's methods, but a broader audience will be interested in the topic from the standpoint of why quality of service is important to customer satisfaction and, ultimately, ridership generation and retention.

Methods Chapters

The focus of the methods chapters is on providing computational methods for evaluating quality of service, a specific transit mode or facility's capacity, and related performance measures. Engineers and planners who wish to perform capacity and quality of service analyses will find step-by-step instructions within the Methodology sections of these chapters. Worked problems illustrating the calculation process are provided within the chapters' Calculation Examples sections.

Most chapters also provide supporting material that will be of interest to broader audiences. The first few sections of most capacity-focused chapters (Chapters 6–10) provide *mode-specific concepts* information that supplements the general concepts material in Chapter 3, Operations Concepts. This information will be useful for staff, consultants, and students working with or learning about a specific transit mode or transit passenger facilities. Most chapters also provide *applications* sections that show how a chapter's methods can be incorporated into common transit planning and operations activities.

There are six methods chapters:

- *Chapter 5, Quality of Service Methods*, provides methods, applications, and examples of evaluating fixed-route and demand response transit availability, comfort, and convenience from the passenger perspective. The chapter also presents a method for evaluating transit level of service as part of a multimodal evaluation.
- *Chapter 6, Bus Transit Capacity*, presents factors specific to bus transit that impact bus capacity, speed, and reliability, and describes the infrastructure treatments and operational measures that can improve bus performance in one or more of these areas. Individual sections provide computational methods for evaluating bus capacity and speed, while a section on bus reliability presents more general information on the causes of bus unreliability, as research has not yet developed computational methods for forecasting reliability.

- *Chapter 7, Demand-Responsive Transit*, describes the factors that influence DRT capacity, presents four potential approaches for estimating the number of vehicles and vehicle service hours required to serve a given demand for DRT service, and points readers to several sources for estimating DRT demand.
- *Chapter 8, Rail Transit Capacity*, begins with sections on rail-specific capacity concepts and primers on train control and signaling and train operations. Computational methods are provided for estimating the capacity of various modes and configurations of rail transit systems, including guidance on measuring or estimating input values used by the methods.
- *Chapter 9, Ferry Transit Capacity*, starts with sections describing the aspects of ferry service, facilities, scheduling, and service planning that are unique to the mode. Computational methods are provided for estimating the number of ferry vessels per hour that a dock or berth can accommodate, along with the number of passengers and autos that can be carried onboard vessels.
- *Chapter 10, Station Capacity*, begins by discussing three themes that appear throughout the chapter: access for persons with disabilities, emergency evacuation, and security. The chapter describes the range of transit stops and stations that exist and their typical features, the variety of passenger circulation features found within stations, and methods for evaluating and sizing those features. The chapter also describes options for transit vehicle, private vehicle, and bicycle circulation and storage outside of stations.

Reference Chapters and Supporting Material

Glossary and Index

Two chapters at the end of the manual provide reference material supporting the rest of the manual. *Chapter 11, Glossary and Symbols*, provides a comprehensive transit glossary along with a list of the variables used in the TCQSM's computational methods. *Chapter 12, Index*, as its name suggests, provides an index to the manual.

CD-ROM

The CD-ROM that accompanies the manual provides supplemental material that supports the printed manual:

- **PDF chapter files.** The CD-ROM provides PDF versions of each TCQSM chapter that can be copied to computers, tablets, and other devices for easier portability. Users may also wish to print out the chapter(s) they use most often as an alternative to the larger book. The PDF versions of the chapters also include hyperlinks that allow readers to jump directly to a cross-reference or a document referenced by the manual.
- **Computational spreadsheets.** To assist TCQSM users in applying the methods presented in the bus, rail, and ferry capacity chapters, the CD-ROM provides Microsoft Excel spreadsheets that automate these modes' computational methods. *Neither TRB nor the research team that developed the TCQSM provide support for these spreadsheets.* Other chapters' methods are either readily performed by hand or are better suited for other types of software tools, such as GIS software.

- **Reference library.** The CD-ROM provides links to PDF versions of all of the TCRP reports referenced in the manual.
- **Training material.** To assist new users in applying TCQSM methods, the CD-ROM provides a series of narrated PowerPoint presentations ranging from a half-hour to an hour in length that introduce the main quality of service and capacity concepts and methods provided in the TCQSM. The CD-ROM also provides an executive summary of the manual in PDF format, particularly designed to educate transit agency management and board members about how the manual can be used to help improve agency activities.

Website

TRB's Committee on Transit Capacity and Quality of Service maintains the www.tcqsm.org website on a volunteer basis. At a minimum, the website is anticipated to provide links to major new research relevant to the TCQSM that is released prior to the next major TCQSM update, any errata or clarifications for the manual that the committee develops, and links to the electronic version of the manual and supporting material. Other features may also be provided on the website, depending on committee member interest and time availability.

HOW TO FIND MATERIAL OF INTEREST

There are a variety of ways to quickly find material of interest within the manual:

- **Tables of Contents.** The manual's front matter provides a master table of contents, and individual chapters provide a table of contents and list of exhibits (tables and figures) specific to that chapter. Readers can browse the section heads to identify which sections are of interest to them.
- **"How to Use" sections.** The preceding "How to Use the Manual" section provides an overview of the manual's organization. Each chapter also provides an Introduction section that outlines the chapter's contents, provides a "How to Use This Chapter" section, and points to related material in other chapters and on the CD-ROM.
- **Index.** The index (Chapter 12) identifies where key material is discussed in different sections of the manual.
- **PDF chapters.** The PDF versions of individual chapters can be searched for specific words or phrases. The PDF file's bookmarks list all of the subsections within a given chapter, not just the main subsections listed in the chapter table of contents. All hyperlinks in the PDF files are active at the time of this printing and can be used to quickly get to supporting information.
- **Reference library.** Links to all of the TCRP reports referenced by the TCQSM are included on the CD-ROM. These reports provide background about how TCQSM methods were originally developed and—for topics tangential to the TCQSM's scope—provide details not covered in the TCQSM.

- **Hyperlinks.** A number of other documents referenced by the TCQSM were available on the Internet at the time of writing. Hyperlinks to these documents are provided in each chapter's References section.
- **Margin notes.** Margin notes, like the one to the left about the changeable nature of hyperlinks, are used to highlight key points of interest.

Hyperlinks, like all Internet content, are subject to change. If a link no longer works, try searching for the document name in an Internet search engine.

FIVE KEY CONCEPTS

Five key concepts appear throughout the manual. While these concepts are fleshed out in Chapters 3 and 4, they are introduced here because they are so fundamental to understanding and applying the manual.

Quality of Service

Quality of service is the overall measured or perceived performance of transit service from the passenger's point of view.

While there are many valid perspectives for assessing transit performance, the TCQSM focuses on the passenger or customer point-of-view, while acknowledging that transit operators must strike a balance between the quality of service that passengers would ideally like and the quality of service that a transit agency (*a*) can afford to provide or (*b*) would reasonably provide, given the demand for transit service.

The performance measures used to describe quality of service are different from the financial and output-focused performance measures that have traditionally been used in the transit industry. Quality of service focuses on two areas:

1. *Transit availability*—Is transit service an option for a given trip?
2. *Transit comfort and convenience*—If transit service is an option, how attractive is it to potential passengers?

The quality of service provided depends on the operating decisions made by a transit agency within the constraints of its budget, particularly decisions as to where transit service should be provided, how often and how long it is provided, and how it is provided. These decisions in turn, are often guided by the agency's goals and objectives.

Capacity

Capacity reflects the maximum number of transit vehicles, persons, or both, that can travel past a particular location in a given period of time under specified conditions. There are several types of capacity discussed in the TCQSM:

- *Maximum (theoretical) capacity* reflects the greatest number of persons or transit vehicles that can be served *under any circumstance*. Maximum capacity is an unstable—and thus unreliable—form of operation. In the case of persons, maximum capacity is achieved under crush loading conditions, when as many people are squeezed onto a vehicle as is physically possible—a condition that North American passengers will only accept under exceptional circumstances. Consequently, maximum capacity should not be used for typical planning and operations applications.

Unless the TCQSM specifically states “maximum capacity,” design capacity is meant.

- *Design (achievable, practical) capacity* reflects the number of persons or transit vehicles that can be served at a specified quality of service (e.g., design loading level, design reliability level). The TCQSM estimates design capacity, except when the term “maximum capacity” is specifically used. Greater volumes of persons or transit vehicles than the design capacity may be served on occasion, but not on a regular basis.
- *Vehicle (bus, train, vessel) capacity* is measured in vehicles per hour and expresses how many transit vehicles can pass a point in an hour.
- *Passenger capacity* is measured in persons per vehicle and expresses how many persons a transit vehicle can carry at a design passenger loading level.
- *Person capacity* is measured in persons per hour and expresses how many persons can pass a point in an hour. It is the product of vehicle and passenger capacity.

Speed and Reliability

Because speed and reliability are not included in the TCQSM’s title, they can be easily overlooked amid all of the manual’s other content. Furthermore, because capacity is not an issue for many transit agencies, it can be easy to assume that the manual’s capacity chapters have no application to small- and mid-sized transit agencies. However, that assumption would be a mistake.

Speed (or, more accurately, travel time) and reliability are important quality of service attributes to passengers and thus influence transit ridership. At the same time, speed and reliability directly influence the time scheduled for a transit vehicle on a route. The scheduled travel time, in turn, determines the number of vehicles required to operate the route at a given service frequency and thus the route’s operating and capital costs. Ridership and the cost of providing service are issues that affect all sizes of transit agencies.

The same factors that affect transit capacity also affect transit speed and reliability. Therefore, speed and reliability are addressed side-by-side with capacity in the manual’s concepts and methods chapters. Although determining transit capacity may not be the ultimate goal of an analysis, calculating it allows other useful information, such as speed and reliability, to be determined.

Definitions

The transit industry, like many others, has developed its own vocabulary over the years. To someone new to public transit, these terms may be unfamiliar. To help these readers, the TCQSM uses *italics* in the text to identify terms and phrases as they are defined for the first time. The manual also includes a transit glossary (Chapter 11) that compiles all of these terms, plus many others used in transit planning and operations outside the areas of capacity and quality of service.

Complicating matters, the use of terminology is not consistent across the industry. Many transit systems have their own specific, historically derived, terminology: a motorman and guard on one system can be an operator and conductor on another. Modal definitions can be confusing. What is clearly light rail by definition may be termed streetcar, semi-metro, or rapid transit in a specific city. It is recommended that in these cases local usage should prevail. However, it is important to be aware of the

TCQSM's definition of a particular term when applying TCQSM methods, as it may differ from local usage.

Local Data

The TCQSM has compiled data and methods from a variety of sources and produces estimates that reflect average conditions. However, the manual recommends that for the best results, *local data should be used whenever possible*, as every location will have its own unique characteristics that may not reflect North American averages. When local data are not available, the TCQSM's default values may be substituted. In these cases, it is recommended that the sensitivity of important results to changes in assumptions be tested. The series of illustrative exhibits in Chapter 3, Operations Concepts that show the impacts of various factors on speed and capacity can be used to identify which assumptions may be particularly important to check.

2. PURPOSE AND SCOPE

PURPOSE AND OBJECTIVES

The *Transit Capacity and Quality of Service Manual* (TCQSM) provides transportation practitioners with a consistent set of techniques for evaluating the quality of service and capacity of transit services, facilities, and systems. The manual's objectives include providing the latest research results on estimating and assessing the capacity, speed, reliability, and quality of service transit services, facilities, and systems; providing methods for performing these estimates and assessments; and presenting computational examples illustrating the application of the manual's methods.

SCOPE

The TCQSM is the primary source document incorporating research findings on transit capacity, speed, reliability, and quality of service. A companion document, the *Highway Capacity Manual 2010* (3), presents methods for evaluating the quality of service of roadway, pedestrian, and bicycle facilities.

The TCQSM is not a standards document. The methods contained within the TCQSM, while representing the best available knowledge at the time of publication, do not set policies regarding a desirable or appropriate quality of service or capacity of a transit service, facility, or system.

The TCQSM does not provide tools for directly estimating the ridership generated by a particular transit service or system, although it does provide guidance on changes in ridership that might be expected to accompany changes in quality of service, and also provides information on the relative contributions of land use, demographic, and transportation demand management (TDM) to ridership. Readers are encouraged to refer to texts on travel demand modeling for more information on transit ridership estimation.

INTENDED USERS

The TCQSM is intended for use by a range of practitioners, including transit planners, transportation planners, traffic engineers, transit operations personnel, design engineers, management personnel, teachers, and university students. To use the manual effectively and to apply its methodologies, some technical background is desirable, typically university-level training or technical work in a public agency or consulting firm.

POTENTIAL APPLICATIONS

The TCQSM has many potential applications, and provides "Applications" sections within its methodological chapters that describe how the methods can be applied to address real-world transit operations, planning, and design needs. Example applications include:

- **Training.** The manual's concepts chapters provide an introduction to transit modes, operations, and quality of service to readers new to the transit industry. Potential users include new agency employees in their first job in the transit

agency, new transit agency board members, consulting staff who have not previously worked on transit projects, and university students and professors.

- **Reference.** The manual is filled with useful information that can be looked up as needed. Examples include service times associated with different fare-collection methods, areas taken up by persons carrying large objects, ridership responses to changes in quality of service, and a comprehensive transit glossary.
- **Guidance.** The manual provides guidance on a number of topics within its scope, including potential applications and effects of transit preferential treatments and operational tools (for example, transit signal priority, curb extensions, and stop consolidation), the role of simulation in operations analysis, and ways to design transit systems to accommodate future growth.
- **Service Standards Development.** The TCQSM's quality of service material is presented in a manner that facilitates the development of passenger-focused service standards. Quality of service tables for different factors (service frequency, passenger loading, etc.) describe both the passenger and transit operator perspectives associated with different service levels, and the accompanying text describes the potential ridership and operating cost implications of changes in quality of service.
- **Service Evaluation.** TCQSM methods can be used to diagnose and treat operational issues. The manual also provides standard definitions of quality of service-related performance measures that can be used for one-time service evaluations, incorporated into an agency performance-measurement program, or used as a part of a peer review process.
- **What-If Questions.** The manual's methods can be used to evaluate the transit operations and quality of service impacts of potential changes (e.g., introducing a new fare-collection system or developing a bus lane on a street). The manual's concepts material can be used to support an agency's response to service-related questions (e.g., from passengers, board members, or the media); it can also be used by transit and planning agencies to identify issues to consider when contemplating introducing new transit modes or service types.
- **Planning.** The manual's contents support both sketch-planning applications, providing quick, approximate answers about the expected operational performance and quality of service of a particular mode or alternative (via graphs and tables), or more precise answers, using the manual's computational methods. Potential uses include transit development plans, long-range transportation plans, and alternatives analyses.
- **Design.** The TCQSM's computational methods can be used to support a variety of transit design activities, including sizing transit centers (e.g., number of bus bays to provide), designing BRT service (e.g., platform length needed to meet a given ridership demand using a particular type of vehicle while providing a specified quality of service), and sizing passenger circulation elements of new and remodeled transit stations.

INTERNATIONAL USE

Applications

In producing the TCQSM with metric units, TRB has taken a step toward making these methods and procedures more applicable to international work. However, the user of the manual is cautioned that the majority of the research base, the default values, and the typical applications are from North America, particularly the United States. Although there is considerable value in the general methods presented, their use outside of North America will likely require calibrating the inputs to TCQSM methods to local conditions, particularly in regard to (4):

- Differences in passenger sizes and tolerances for crowding, which may lead to higher design loads than would be accepted in North America;
- Differences in transit vehicles from those used in North America, including vehicle types, sizes, number of doors, and interior layouts;
- Differences in the composition of traffic on streets used by transit vehicles, particularly the amount of 2- and 3-wheeled vehicles on the road and the number of pedestrians crossing the road;
- Differences in driving cultures with respect to obeying the rules of the road;
- Differences in ability to convert roadway space to transit lanes; and
- Differences in labor costs compared to North America, which may make transit service feasible under different conditions than in North America.

The World Bank has published a reference document (4) that highlights these differences and provides capacity procedures for developing cities that are modeled on TCQSM methods, but which use inputs typical of the conditions found in those cities.

Measurement Units

This edition of the TCQSM has been published in dual units, U.S. customary and metric. In general, U.S. customary units are presented first, with metric units as supplemental units, except in cases where the source material used metric units as the primary units, in which case metric units are presented first. Exhibit 1-2 provides common measurement unit abbreviations used in the TCQSM.

Exhibit 1-2
Measurement Unit
Abbreviations Used in
the TCQSM

Measurement Type	US Customary Units	Metric Units
Length, width, depth, distance	inches (in.)	millimeters (mm)
	feet (ft)	meters (m)
	miles (mi)	kilometers (km)
Area	acres (acre)	hectares (ha)
Time	seconds (s)	seconds (s)
	minutes (min)	minutes (min)
	hours (h)	hours (h)
Speed, travel time rate	miles per hour (mi/h)	kilometers per hour (km/h)
	minutes per mile (min/mi)	minutes per kilometer (min/km)
Acceleration	feet per second squared (ft/s ²)	meters per second squared (m/s ²)
Capacity	vehicles per hour (veh/h)	vehicles per hour (veh/h)
	passengers per hour (p/h)	passengers per hour (p/h)
Space	passengers per square foot (p/ft ²)	passengers per square meter (p/m ²)

When converting between measurement units, an equivalent level of precision is used. For example, the range of subway platform lengths of 300 ft to more than 1,000 ft is presented as 90 m to more than 300 m (i.e., rounded to a comparable level of precision). The 40-ft standard bus is given as 12 m in metric units. A maximum train speed of 50.1 mi/h (i.e., presented with one decimal of precision) would be shown as 80.6 km/h in metric units.

3. WHAT'S NEW IN THE THIRD EDITION

Each edition of the TCQSM builds on the foundation laid by the preceding edition, while adapting the presentation to meet current user needs and incorporating the latest research findings. The work of TCRP Project A-15C, which developed this edition of the TCQSM, included an extensive user outreach effort (including focus groups in six locations in the U.S. and Canada and an online survey) to obtain user feedback on the 2nd Edition. This feedback helped shape the 3rd Edition's organization and content. In addition, TCRP Project A-15C reviewed new research performed since the development of the 2nd Edition to identify areas where existing content could be updated. The results of this work can be seen in the changes to the manual's organization and content that are described in this section.

ORGANIZATIONAL CHANGES

The user outreach effort identified that the TCQSM has a variety of users who possess a range of backgrounds, both technical and non-technical. The latter group of users wants to know about transit capacity and quality of service concepts and about the relative impacts of various factors on capacity and quality of service, but does not need to perform specific calculations. To help this group of users, the 3rd Edition provides a clear separation between concepts and computational methods both through the presentation of chapters within the overall manual and through the presentation of material within individual chapters. This approach provides non-technical users with the information they need while lessening the perception that the TCQSM is solely an engineering reference. At the same time, the TCQSM still provides a full range of material for technical users, and all of the information that might be used in a computation (e.g., default values) is now provided alongside the methods they are used in, rather than being split between concepts and methods. Calculation examples are still provided, and the manual's computational spreadsheets have been updated.

Another significant change is that background material that ages rapidly (e.g., ridership statistics) has been removed from the TCQSM and replaced with references to sources for the latest information. This was done in response to user feedback that the material made the TCQSM seem dated as time passed after its publication date, even though the manual's core concepts and methods were still up-to-date.

Finally, the outreach revealed that, in the absence of other comprehensive reference works, many users look to the TCQSM for information that lies outside the TCQSM's scope. While the TCQSM cannot be everything to everybody, this edition takes particular care to refer readers to references tangentially related to the TCQSM that may provide the information they are looking for. Thus, the TCQSM provides the framework for capacity and quality of service analysis and identifies the necessary inputs to computational methods, but does not necessarily provide the tools for estimating every input to a method, possibly relying instead on references to other specialty documents.

CONTENT CHANGES

This section summarizes important content changes—both concepts and methods—by chapter. All chapters have many other small changes, mainly designed to improve the presentation of material or to update statistics and examples.

Chapter 2: Mode and Service Concepts

This chapter incorporates much of the material from Part 2, Transit in North America, in the 2nd Edition. New trends that appeared in the first decade of the 2000s in transit vehicle types (e.g., low-floor vehicles, different power sources) and their resulting impacts on transit speed and capacity are discussed. The demand-response transit material has been updated with information about the impacts on technology on service provision and the latest ADA requirements. The latest trends in North American fixed-guideway transit are described, such as the growing number of bus rapid transit (BRT) and modern streetcar services, and an expansion in the number and size of light rail systems. A new section has been added describing transit service patterns and their potential quality of service impacts. Finally, guidance has been added on transitioning demand-response service types to ones providing more or less flexibility.

Chapter 3: Operations Concepts

Chapter 3 incorporates the transit capacity and speed concepts material that previously appeared in Parts 4–6 (Bus, Rail, and Ferry Capacity, respectively) in the 2nd Edition. The presentation of these concepts in the 3rd Edition is intended to be mode-neutral to the extent possible, as several different modes are often capable of providing a desired capacity, speed, or both. Many new figures appear in the chapter that illustrate the relative impact of specific factors on transit capacity and speed, to help readers better understand which factors have the greatest influence.

Based on user feedback, a new section has been added on passenger demand characteristics, summarizing the latest research on the relative influence of demographics and transportation demand management (TDM) strategies on ridership. In addition, guidance on land use densities capable of supporting a given level and type of transit service has been updated and expanded. Other new material includes a section on the influence of transit operating environment (right-of-way) on capacity, speed, and reliability.

Chapter 4: Quality of Service Concepts

Concepts material that previously appeared in Part 3, Quality of Service, in the 2nd Edition is presented in Chapter 4 in the 3rd Edition. A new section has been added on passenger perceptions of value of time at different stages of their trip and under different conditions. Information on average walking distances to transit has been updated based on new research, and material on pedestrian, bicycle, and park-and-ride access to transit has been expanded. A new section is provided on how passengers schedule their trips to compensate for unreliable service and the resulting impacts on overall passenger travel time.

In response to user feedback on the 2nd Edition, additional information is provided on ridership responses to changes in quality of service, based on new research. Also, a

new section has been added that discusses the potential operating and capital cost implications of improving quality of service.

Chapter 5: Quality of Service Methods

Chapter 5 incorporates the remainder of the material found in Part 3, Quality of Service, in the 2nd Edition. The biggest change in this section is the elimination of level of service (LOS) letters associated with the transit quality of service measures. This was done in response to user feedback (primarily from transit agencies) that the LOS letters were an impediment to adopting and using the manual's quality of service framework because the letters were too closely associated with school grades. Eliminating the letters has also allowed the quality of service tables to show more or fewer service levels, as appropriate, rather than being forced to fit the levels to the six letters, as before. Furthermore, the quality of service tables now include a column presenting the transit agency point of view alongside the passenger point of view, to better illustrate the trade-offs involved in moving from one service level to another. In combination, these changes are designed to make it easier for transit agencies to develop service standards that incorporate quality of service, while balancing an agency's goals regarding service delivery with its budgetary constraints.

At the same time, recognizing that other users (primarily metropolitan planning organizations [MPOs] and roadway agencies) use LOS to evaluate other modes and are generally comfortable with the LOS concept, transit LOS has not been completely removed from the manual. The multimodal transit LOS measure developed by NCHRP Project 3-70, "Multimodal Level of Service Analysis for Urban Streets," has been added to meet the needs of transportation planners and engineers. This measure provides a single transit LOS letter as its output, while incorporating most of the factors included in the manual's transit quality of service framework. This measure can also be incorporated into an overall evaluation of the quality of service provided to all roadway users—transit passengers, pedestrians, bicyclists, and motorists. The multimodal transit LOS measure also addresses another user concern with the TCQSM's LOS system, specifically, that interpreting and reporting six different LOS measures was difficult.

The fixed route quality of service framework has also changed in that the stop, route, and system elements of the framework have been removed. (Previously, each quality of service measure was associated with either stop, route, or system evaluation.) Instead, guidance is provided for each element of the framework on its application to stop, route, and system evaluation, as appropriate. In addition, the demand-responsive transit framework has been completely updated.

The final major change is that a new section on applications has been added, demonstrating the potential usage of the TCQSM's quality of service measures in a variety of planning and operations analysis contexts.

A number of other smaller changes have also been made. Additional information is provided on evaluating transit access at a stop level, particularly bicycle access to transit. Information about the space consumed by transit passengers and their items has been updated. An additional measure of transit reliability, *excess wait time*, is introduced. The basis of the transit-auto travel time measure has changed from the absolute difference in travel times to a ratio of travel times, to allow it to be applied more easily in different sized communities. A section has been added on safety and security performance measures. Finally, the computational examples have been

updated to reflect the changes to the quality of service framework and to add an example of evaluating multimodal transit LOS.

Chapter 6: Bus Transit Capacity

Chapter 6 incorporates the majority of the fixed route bus material previously found in Part 4 of the 2nd Edition, Bus Transit Capacity. The section on transit preferential treatments has been split into two sections: one on infrastructure treatments (updated based on new research) and one on operations strategies. The bus capacity method, previously separated into separate busway, bus lane, and mixed traffic methods, is now presented as a unified method, with a set of step-by-step instructions. The bus speed method is now also presented step by step, and the calculation of base bus speed has been updated to allow the speed to be calculated directly for any combination of bus stop spacing, dwell time, posted speed, and bus acceleration characteristics. Material on bus reliability has been moved into a new section in the chapter and updated based on the latest research. Finally, a new section on applying the bus methods to real-world planning and design applications has been added.

Smaller changes to the chapter include a new table on bus performance characteristics, updates to the table of passenger service times associated with different fare collection methods, and introduction of a *boarding lost time* factor that accounts for the time required for boarding passengers to make their way to a bus at bus stops with more than one loading area.

Chapter 7: Demand-Responsive Transit

The DRT material previously found in Part 4, Bus Transit Capacity, in the 2nd Edition has been moved into its own chapter in the 3rd Edition. This material has been completely updated and includes a discussion of the factors that influence DRT capacity, a discussion of available methods for estimating DRT capacity in different operating environments, and a discussion of the importance of ridership demand in estimating DRT capacity.

Chapter 8: Rail Transit Capacity

The majority of the material that previously appeared in Part 5, Rail Transit Capacity, in the 2nd Edition now appears in Chapter 8. Significant new material has been added on the respective roles of simulation and sketch planning tools in evaluating rail capacity. Other new material includes a discussion of the role of the vehicle–platform interface in influencing capacity, along with a discussion of platform screen doors. The discussions of design capacity and on-street rail preferential treatments have been updated. The capacity equations, while producing the same results as before, have been adjusted to (a) match the way percentages are entered elsewhere in the manual (e.g., 0.75 instead of 75) and (b) clarify the units embedded in conversion factors.

Chapter 9: Ferry Transit Capacity

Ferry transit material formerly found in Part 6, Ferry Transit Capacity, in the 2nd Edition has moved to Chapter 9 in the 3rd Edition. The basic methodology is the same as before, but additional material has been added throughout the chapter, particularly related to the flow of passengers through ferry terminals and impacts of security procedures on overall capacity.

Chapter 10: Station Capacity

Material from Part 7, Stop, Station, and Terminal Capacity, in the 2nd Edition now appears in Chapter 10. Information relating to ADA and fire code (NFPA 130) requirements has been updated to reflect the standards in effect at the time of writing.

Although many of the procedures for sizing individual station elements are unchanged, there have been some significant additions to the chapter. These include a supplemental method for estimating stairway capacity based on the number of pedestrian lanes provided (as opposed to the width-based method) and new sections on platform clearance analysis and alternative performance measures. A new section on applications includes an extensive discussion of the role of simulation in evaluating station pedestrian circulation and the computational examples include new examples of sizing transit centers and applying microsimulation software.

Other changes include expanded descriptions of the various transit station types. A new section devoted to vehicle circulation and storage at stations includes new material on estimating the number of bus berths at off-street bus stops, typical amounts of automobile parking provided at transit stations, and bicycle parking provisions. Finally, updated information on fare purchase and fare control is provided.

Chapter 11: Glossary and Symbols

The glossary has been updated to reflect changes to definitions and new terms that have been added to the 3rd Edition. The list of symbols has been updated to reflect their usage in the 3rd Edition.

4. COMPANION DOCUMENTS

This section describes important documents that cover topics outside the TCQSM's scope, and which may need to be consulted when performing a TCQSM analysis.

HIGHWAY CAPACITY MANUAL

The *Highway Capacity Manual 2010* (HCM 2010, 3) provides methods for estimating vehicle capacity on urban streets. The volume-to-capacity ratio of the curb lane (and possibly the adjacent lane) is an input to the TCQSM's bus capacity method, when buses operate in mixed traffic or in exclusive lanes. The HCM's procedures for estimating bus speeds on urban streets can also be used as an alternative to the TCQSM's procedures, when the specific signal timing used on the street is important to the analysis. Finally, the HCM provides methods for estimating multimodal bicycle, pedestrian, and automobile LOS on urban streets that complement the TCQSM's multimodal transit LOS method.

AMERICANS WITH DISABILITIES ACT (ADA) STANDARDS FOR TRANSPORTATION FACILITIES

The *ADA Standards for Transportation Facilities* (5) "apply to the construction or alteration of transportation facilities covered by the ADA." The standards may specify minimum dimensions for transit stop or station elements that are greater than the dimensions determined by Chapter 10 methods as the minimum needed to provide a desired passenger circulation capacity or quality of service.

NATIONAL FIRE PREVENTION ASSOCIATION (NFPA) 130 STANDARD

NFPA 130 (6) provides standards for emergency evacuation that must be considered as part of station design. When the minimum size for a station passenger circulation element specified by NFPA 130 is greater than the minimum size determined by TCQSM methods as being needed to provide a desired quality of service, the larger size required for emergency evacuation should be used.

5. REFERENCES

Links to the TCRP reports listed here can also be found on the accompanying CD-ROM.

1. Kittelson & Associates, Inc.; Texas Transportation Institute; and Transport Consulting, Ltd. *TCRP Web-Only Document 6: Transit Capacity and Quality of Service Manual*, 1st Edition. Transportation Research Board, National Research Council, Washington, D.C., January 1999.
http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_webdoc_6-a.pdf
2. Kittelson & Associates, Inc.; KFH Group, Inc.; Parsons Brinckerhoff Quade & Douglass, Inc.; and K. Hunter-Zaworski. *TCRP Report 100: Transit Capacity and Quality of Service Manual*, 2nd Edition. Transportation Research Board of the National Academies, Washington, D.C., 2003.
<http://www.trb.org/Main/Blurbs/153590.aspx>
3. *Highway Capacity Manual 2010*. Transportation Research Board of the National Academies, Washington, D.C., 2010.
4. Reilly, J. and H. Levinson. *Public Transport Capacity Analysis Procedures for Developing Cities*. The International Bank for Reconstruction and Development/The World Bank, Washington, D.C., 2011.
<http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1239112757744/5997693-1294344242332/Public-Transport-Capacity-Analysis-Procedures.pdf>
5. U.S. Department of Transportation. *ADA Standards for Transportation Facilities*. <http://www.access-board.gov/ada-aba/ada-standards-dot.cfm>, accessed January 22, 2013.
6. National Fire Protection Association. *NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems*. Washington, D.C., 2010.