

# *New Transit Capacity and Quality of Service Manual*

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## **ABSTRACT**

A new *Transit Capacity and Quality of Service Manual* has been published that represents a synthesis of North American practice related to transit capacity and quality of service. The manual addresses both bus and rail transit modes and transit terminals, and includes basic capacity concepts, detailed analytical procedures, and sample problems. The manual also includes a systematic approach to assessing transit quality of service from the passenger point-of-view, and includes a transit quality of service framework that relates service measures to transit availability and quality, for transit stops, route segments, and systems.

## **1. INTRODUCTION**

In 1999, the U.S. Transit Cooperative Research Program (TCRP) completed a two-year study to develop updated principles, practices, and procedures for transit capacity and quality of service. The study was conducted with the focus of developing a new *Transit Capacity and Quality of Service Manual* (TCQSM), intended to be a comprehensive document summarizing transit capacity and quality of service concepts, procedures, and applications. Three other key components of the study included updating the transit chapters in the new year 2000 *Highway Capacity Manual* (HCM2000), identifying overall research needs in transit capacity and quality of service, and conducting research in identified areas.

For years, the transportation profession in North America had lacked a consolidated and generally accepted set of transit capacity and quality of service definitions, principles, practices, and procedures for planning, designing, and operating vehicles and facilities. This was in contrast to the *Highway Capacity Manual* that defines quality of service and presents fundamental information and analytical procedures related to quality of service and capacity of highway facilities. In the absence of a comparable, authoritative document, the case for transit service and enhancements in a multi-modal environment was weakened. Therefore, there was a need for a *Transit Capacity and Quality of Service Manual*.

In 1995, the U.S. Federal Transit Administration (FTA) developed a research statement for a comprehensive research program on transit capacity and quality of service, which was submitted to TCRP for possible funding. The program included the development of a new *Transit Capacity and Quality of Service Manual*, and undertaking research on ten different transit capacity and quality of service topics. TCRP took this proposal and transformed it into the A-15 research project, *Development of Transit Capacity and Quality of Service Principles, Practices, and Procedures*. In addition to the preparation of a new TCQSM, the project included revisions to the transit chapters being prepared for the new year 2000 *Highway*

*Capacity Manual* (HCM2000), as well as identifying a prioritized set of transit capacity and quality of service research needs, and undertaking the identified top priority research. The A-15 project was initiated in November 1996 and was completed in January 1999.

Kittelson & Associates, Inc., served as the prime contractor for the TCRP A-15 project, assisted by the Texas Transportation Institute and Transport Consulting Limited.

## **2. INPUT FROM POTENTIAL USERS ON THE CONTENT OF THE TCQSM**

To help identify the desired content of a new *Transit Capacity and Quality of Service Manual* by potential users, a stakeholders survey was conducted at the outset of the A-15 project. Seven different groups were targeted, with a total of 411 questionnaires distributed:

- Large Urban Transit Systems (>200,000 population) - 181 surveyed,
- Small Urban Transit Systems (<200,000 population) - 105 surveyed,
- Paratransit Systems - 23 surveyed,
- Cities/Counties - 24 surveyed,
- Metropolitan Planning Organizations - 21 surveyed,
- State Departments of Transportation - 24 surveyed, and
- Professionals (Consultants, Academicians) - 23 surveyed.

One of the questions asked was whether agencies or individuals used specific documents to analyze transit capacity and quality of service. The most frequently used document was the *Highway Capacity Manual* (23%). Many agencies not using published documents used in-house evaluation procedures. A third of the respondents indicated they did not have any procedures they use. Ninety-four percent (94%) of the survey respondents indicated they would use a new *Transit Capacity and Quality of Service Manual*, if available.

A set of questions in the stakeholders survey related to the desired content of the new TCQSM. When asked if the TCQSM should have an “applications” theme, 79% agreed. Eighty-one percent (81%) agreed that the TCQSM should be structured similar to the existing *Highway Capacity Manual*. Ninety-one percent (91%) of the survey respondents agreed that examples illustrating different applications of transit capacity and quality of service analysis procedures should be included in the TCQSM.

In addition to the Stakeholders Survey, over 70 publications which addressed some element of transit capacity and/or quality of service were reviewed as part of the A-15 project, and summarized in an extensive annotated bibliography.

## **3. TCQSM CONTENT OVERVIEW**

The new *Transit Capacity and Quality of Service Manual*, is intended to be a comprehensive guide for use by transit planners and engineers to obtain information on capacity characteristics of different types of transit systems, capacity analytical procedures,

and quality and level of service concepts and measures. The manual is a new TCRP Report publication (Web Document No. 6), with the intent of being updated periodically under the guidance of the TRB Task Force on Transit Capacity and Quality of Service, which was established in 1998.

The TCQSM addresses capacity and quality of service for the following transit modes:

#### Bus

- Fixed-Route
- Demand-Responsive

#### Rail

- Light Rail Transit/Streetcar
- Heavy Rapid Transit
- Commuter Rail
- Automated Guideway Transit.

The TCQSM is divided into six parts:

1. Introduction and Concepts,
2. Bus Transit Capacity,
3. Rail Transit Capacity,
4. Terminal Capacity,
5. Quality of Service, and
6. Glossary.

Over 200 exhibits are included in the manual. The manual presents both metric and U.S. customary units (with customary units in parentheses). Table 1 identifies the table of contents of the TCQSM.

### **3.1 TCQSM Part 1: Concepts and Definitions**

At the outset of the TCQSM, a general part on transit concepts and definitions is provided. This part of the manual provides the framework for the more detailed presentation of transit capacity and quality of service analytical procedures later in the manual. This part defines transit quality of service and level of service, and identifies the different types of transit modes and service addressed in the manual. The concept of vehicle capacity vs. person capacity is also addressed.

### **3.2 TCQSM Part 2: Bus Transit Capacity**

Analytical procedures to identify bus vehicle and person capacity are addressed in this part of the manual. The procedures address bus capacity for four different operating configurations:

1. segregated busway,
2. bus/HOV lane,

**TABLE 1 *Transit Capacity and Quality of Service Manual Table of Contents***

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3. mixed traffic, and
4. demand-responsive.

Procedures for calculating passenger loading and bus dwell times at stops are identified, as well as an assessment of the impacts of bus signal priority.

### **3.3 TCQSM Part 3: Rail Transit Capacity**

This part of the TCQSM incorporates to a large part the TCRP A-8 Rail Transit Capacity research completed in 1996. Rail capacity analytical procedures are presented for rail rapid transit, light rail/streetcar, commuter rail, and automated guideway transit. Capacity factors such as train control and signaling, station dwells, passenger loading levels, and operating issues are addressed.

### **3.4 TCQSM Part 4: Terminal Capacity**

Capacity considerations related to bus stops and rail/bus stations are presented in this part of the TCQSM. For bus stops, application of pedestrian level of service analysis procedures in identifying the required size of passenger waiting areas and adjoining sidewalks and crosswalks are presented. Also procedures for determining the type and number of bus berths are presented. At rail/bus stations, capacity characteristics and sizing of different terminal elements: platforms, escalators, elevators, stairways, walkways, fare gates, and ticket machines, are addressed.

### **3.5 TCQSM Part 5: Quality of Service**

An overall framework of transit performance measures is provided, along with selected service measures and how such measures should be applied to (1) policy and goal setting, (2) service assessment, and (3) facility planning and design.

#### **3.5.1 Definitions**

The definitions used for quality of service, level of service, performance measures, and service measures for the TCQSM are as follows:

*Quality of Service.* Quality of service is the overall measured or perceived quality of transit service from the user or passenger's point of view.

*Transit Performance Measure.* A quantitative or qualitative factor used to evaluate a particular aspect of transit service.

*Transit Service Measure.* A quantitative performance measure that best describes a particular aspect of transit service and represents the passenger's point of view.

*Levels of Service.* Six designated ranges of values for a particular service measure, graded from "A" (best) to "F" (worst), based on a transit passenger's perception of a particular aspect of transit service.

The proposed level of service definition is similar to the one applied in the *Highway Capacity Manual* (HCM). The TCRP A-15 stakeholder's survey also had transit professionals expressing a preference for this system.

### **3.5.2 Basic framework**

Two transit performance measure categories have been proposed:

- *Availability*. Measures that address the spatial and temporal availability of transit service.
- *Quality*. Measures that address user comfort and convenience.

Measures in these two categories, availability and quality, express the user's point-of-view; therefore, the TCQSM presents both service and performance measures for these categories. The term "availability" refers to both the spatial and temporal availability of transit, to avoid confusion with the Americans with Disabilities Act usage of "accessibility." If transit service is located too far away from a potential user or it does not run at the times a user requires the service, that user would not consider transit service to be available. Assuming transit service is available to a potential user, the measures in the "quality" category can be used to evaluate a user's perception of the transit experience.

Different elements of a transit system require different performance measures. The following three categories have been developed:

- *Transit Stops*. Measures addressing transit capacity, utilization, and service quality at a single location. Depending on passenger volumes, scheduling and routing, and stop and station design, these measures will vary from one location to another.
- *Route Segments*. Measures addressing transit capacity, utilization, and service quality along a portion of a route (which can range from two stops to the entire length of a route). These measures should stay the same over the segment being analyzed regardless of conditions at an individual stop.
- *Systems*. Measures addressing transit capacity, utilization, and service quality for more than one route operating within a specified area (e.g., a district, city, or metropolitan area) or of a specified type (e.g., fixed-route vs. demand-responsive). System measures can also address door-to-door travel.

Combining the three transit system elements with the four performance measure categories produces the 3x4 matrix shown in Table 2. Proposed service measures are shown in capital letters, with other performance measures discussed in the TCQSM shown in lowercase.

**TABLE 2 Framework for Transit Performance Measures in the TCQSM**

	<b>Transit Stop</b>	<b>Route Segment</b>	<b>System</b>
<b>Availability</b>	FREQUENCY Passenger loading Ped/bike access ADA accessibility	HOURS OF SERVICE auto access ADA accessibility	SERVICE COVERAGE % person-minutes of avail.
<b>Quality</b>	PASSENGER LOADING Amenities Reliability	RELIABILITY Transit/auto travel time Travel speed	TRANSIT/AUTO TRAVEL TIME Travel time safety

### 3.5.3 Development of LOS measures

The following four key considerations entered into the development of the transit LOS system for the TCQSM:

1. *The transit LOS system should use an A-F scale.* This is based on the responses to the stakeholder survey during Phase 1 of the TCRP A-15 project. The benefits of this system are (1) decision-makers are already familiar with the A-F scale for highways, so less effort will need to be spent by transit agencies educating decision-makers, and (2) the public is already familiar with the A-F scale used for report cards.
2. *The measures should reflect a user's point-of-view.* LOS A, therefore, is not necessarily representative of optimum conditions from a transit operator's point-of-view.
3. *LOS F should represent an undesirable condition from a user's point-of-view.* A transit operator may choose to set higher standards based on their needs or policy goals.
4. *The thresholds for LOS A–E should represent points where a noticeable change in service quality occurs.* However, it is also desirable to have evenly-spaced ranges of values for each LOS grade, to the extent possible.

### 3.6 TCQSM Part 6: Glossary

The glossary includes a comprehensive set of transit terms described in the manual, as well as other common transit industry terms. Over 3,000 entries are included.

## 4. RELATIONSHIP TO TRANSIT PROVISIONS IN THE *HIGHWAY CAPACITY MANUAL*

In addition to the new *Transit Capacity and Quality of Service Manual*, transit provisions will remain in the *Highway Capacity Manual* (HCM), in particular the new HCM2000. Since 1985, there has been a chapter in the HCM devoted to transit (Chapter 12), which addresses transit vehicle and system characteristics, and associated capacity and level of service characteristics. In addition, the impact of transit on traffic operations of different highway facilities (freeway, arterials, signalized intersections) is addressed through adjustment factors in other chapters of the HCM. As part of the development of the new HCM2000, the Transit Subcommittee of the TRB Highway Capacity and Quality of Service

Committee (which is responsible for updating the HCM), is coordinating transit modifications to the HCM2000.

Table 3 identifies the transit topics planned to be included in the HCM2000 vs. the *Transit Capacity and Quality of Service Manual*.

## **5. SUPPLEMENTAL TCRP A-15A RESEARCH**

TCRP has approved a two-year continuation of the A-15 project, entitled A-15A, to conduct further research toward developing a Second Edition of the TCQSM by year 2001. The research will include the following:

1. Development of an Internet web page to allow an opportunity for user feedback on the TCQSM, as well as to provide answers to user questions on interpretation.
2. Testing the transit quality of service framework with respect to four transit service areas:
  - large urbanized with multi-modal transit service,
  - medium-sized urbanized area,
  - small urbanized area, and
  - rural area.
3. Reviewing the TCQSM in its accommodation for persons with disabilities in the capacity procedures and quality of service measures identified, and identifying modifications to reflect Americans with Disabilities Act (ADA) requirements.
4. Surveying transit agencies to obtain updated information on bus passenger service times at stops, and
5. Developing refinements to the transit service availability measure.

## **6. ROLE OF TRB TASK FORCE ON TRANSIT CAPACITY AND QUALITY OF SERVICE**

In late 1996, TRB established a new Task Force on Transit Capacity and Quality of Service. One of the missions of this task force in the future will be to shepherd the application and evolution of the *Transit Capacity and Quality of Service Manual*, including being responsible for updates to the TCQSM. This task force will also promote research on transit capacity and quality of service topics. Strong liaison between the task force and other TRB committees will also be promoted.

**TABLE 3 Transit Topics Addressed in the *Highway Capacity Manual* vs. the *Transit Capacity and Quality of Service Manual***

Topics	Highway Capacity Manual	Transit Capacity and Quality of Service Manual
<b>Glossary</b>	X	X
<b>General Concepts</b>		
• Transit Capacity	X	X
• Transit Quality of Service	X	X
<b>Vehicle Characteristics</b>		
• Fixed-Route Bus		X
• Paratransit Bus		X
• LRT	X	X
• Rapid Transit	X	X
• Commuter Rail	X	X
• Advanced Guideway Transit		X
<b>Transit System Data</b>		
• Fixed-Route Bus	X	X
• Paratransit Bus	X	X
• Light Rail/Streetcar	X	X
• Rapid Transit		X
• Commuter Rail		X
• Advanced Guideway Transit		X
• Transit Preferential Treatments	X	X
<b>Capacity/Quality of Service Scenarios</b>		
• Station/Stop Waiting Area		X
• Vehicle Berthing		X
• On-Board Vehicle		X
• On-Line Operations	X	X
• System	X	X
• Simulation Modeling	X	X
<b>Service Measures</b>		
• Station/Stop Waiting Area		X
• Vehicle Berthing		X
• On-Board Operations	X	X
• System Coverage	X	X
• Effect of System Size	X	X
• Use of Transit Demand Models	X	X
<b>Impact of Transit on Highway Operations</b>		
• Freeway	X	
• Urban Arterial	X	
• Signalized Intersection	X	
• Unsignalized Intersection	X	
• Multi-Lane Highway	X	
• Rural 2-Lane Highway	X	
<b>Sample Problems</b>	X	X
<b>References</b>	X	X

## **7. AVAILABILITY OF TCQSM**

The *Transit Capacity and Quality of Service Manual* has been published as TCRP Web Document No. 6, in PDF format, and is available to be downloaded through the TCRP web site. Select "TCRP, All Projects, A-15" from the TCRP website: <http://www.nas.edu/trb/crp.nsf>. For those persons unable to download the web document, CD-ROM or hard copies of the document can be obtained from TCRP.

## **REFERENCES**

Transit Cooperative Research Program. *Transit Capacity and Quality of Service Manual*, TCRP Web Document No. 6, Washington, D.C., May 1999.