

TRANSIT COOPERATIVE RESEARCH PROGRAM
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TCRP

REPORT 165

Transit Capacity and Quality of Service Manual

Third Edition



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TCRP REPORT 165

Transit Capacity and Quality of Service Manual

Third Edition

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions*, published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard to appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

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The TCQSM, 3rd edition was developed by TCRP Project A-15C. Paul Ryus of Kittelson & Associates, Inc. (KAI) was the Principal Investigator. Co-investigators were Alan Danaher, Mark Walker, Foster Nichols, and William (Bill) Carter of Parsons Brinckerhoff, Inc. (PB); Elizabeth (Buffy) Ellis of KFH Group, Inc.; Linda Cherrington of Texas A&M Transportation Institute (TTI); and Anthony (Tony) Bruzzone of Arup.

Each edition of the TCQSM builds on the material developed for previous editions. The full set of contributors to the 1st and 2nd editions is too numerous to list here, but can be viewed in the acknowledgments sections of those editions. The original authors of material that has been retained between editions are acknowledged below.

The Introduction and Concepts chapters (Chapters 1–4) were written by Paul Ryus, with contributions from Buffy Ellis and Linda Cherrington (demand-response transit, Chapter 2), Daniel Fisher of Arup (value of time, Chapter 4), and Jamie Parks of KAI (bicycle access, Chapter 4). Some rail transit concepts material (Chapter 2) originally written for previous editions by Tom Parkinson has been retained, along with ferry transit concepts (Chapter 2) and park-and-ride material (Chapter 4) originally written by Miranda Blogg. Ferry vessel descriptions were updated based on comments provided by William Hockberger, a member of the TRB Committee on Ferry Transportation.

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FOREWORD

By Dianne S. Schwager

Staff Officer

Transportation Research Board

TCRP Report 165: Transit Capacity and Quality of Service Manual, 3rd edition (TCQSM) is a reference document that provides current research-based guidance on transit capacity and quality of service issues and the factors influencing both. The manual contains background, statistics, and graphics on the various types of public transportation, and it provides a framework for measuring transit availability, comfort, and convenience from the passenger and transit provider points of view. The manual contains quantitative techniques for calculating the capacity and other operational characteristics of bus, rail, demand-responsive, and ferry transit services, as well as transit stops, stations, and terminals. Example calculations are included. The TCQSM and the accompanying CD-ROM are 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.

HISTORY OF THE TCQSM

The TCQSM, 3rd edition updates and improves the prior manuals. Much of the new content and revised presentation in the TCQSM, 3rd edition is a result of outreach in which users and potential users of TCQSM manual identified new or updated content that would make the manual more relevant to their work.

- **The 1st edition, *TCRP Web-Only Document 6*, was produced in 1999**, assembling for the first time in one place a set of methods for evaluating the capacity of bus and rail transit services and facilities, and introducing a framework for evaluating the quality of service from the passenger point of view. A portion of the material in this edition also formed the basis for the transit chapters in the *Highway Capacity Manual 2000*.
- **The 2nd edition, *TCRP Report 100*, was published in late 2003**. A major focus of this edition was on filling 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 guidance on transit preferential treatments and park-and-ride access to transit. This edition tested and enhanced the TCQSM's transit quality of service framework.
- **The 3rd edition of the TCQSM** incorporates the results of new research on transit capacity and quality of service that has occurred in the ten years since the 2nd Edition was developed, including original research conducted as part of the production contract for the manual.

ORGANIZATION OF THE TCQSM 3RD EDITION

The TCQSM 3rd edition consists of twelve chapters, divided into four main topic areas:

- **Introduction.** The introductory chapter provides a concise guide to the TCQSM. It describes how to use the manual; presents the manual's purpose, scope, and intended users; describes the contents of each chapter; highlights the changes made in the 3rd edition; and describes companion documents to the TCQSM.
- **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.
- **Methods Chapters.** The six methods chapters provide a combination of mode-specific concepts information, computational methods for evaluating a variety of performance measures related to transit operations and quality of service, guidance on potential applications of the methods, and worked examples of performing calculations. These chapters address capacity for bus, DRT, rail transit, ferry transit, and stops and stations.
- **Reference Chapters and Supporting Material.** Two chapters at the end of the manual provide reference material supporting the rest of the manual, including a comprehensive transit glossary, a list of the variables used in the TCQSM's computational methods, and an index to the manual.

The CD-ROM that accompanies the TCQSM provides PDF versions of all the TCQSM chapters for use on tablets and computers; links to all of the TCRP reports referenced in the TCQSM; spreadsheets that help perform the calculations used in the bus, ferry, and rail transit capacity methods; and presentations that introduce the manual and its core material.



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11-61 2. LIST OF SYMBOLS

12-1 CHAPTER 12 Index

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI-NA	Airports Council International-North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation