

INFORMATION ITEM

AC TRANSIT DISTRICT
Board of Directors
Executive Summary

GM Memo No. 05-022

Meeting Date: Feb. 2, 2005

Committees:

- | | | | |
|----------------------------|-------------------------------------|------------------------------|--------------------------|
| Planning Committee | <input checked="" type="checkbox"/> | Finance Committee | <input type="checkbox"/> |
| External Affairs Committee | <input type="checkbox"/> | Operations Committee | <input type="checkbox"/> |
| Board of Directors | <input type="checkbox"/> | Financing Corporation | <input type="checkbox"/> |

SUBJECT: Timeline for the review of the Transit Cooperative Research Board (TCRP) Transit Capacity and Quality of Service Manual

RECOMMENDED ACTION:

- Information Only** **Briefing Item** **Recommended Motion**

Fiscal Impact: None

Background/Discussion:

The Transportation Research Board (TRB) recently published the 2nd edition of the *Transit Capacity and Quality of Service Manual*. The document is intended to be a reference for public transit practitioners as well as policy makers. The manual contains background, statistics, and graphics on the various types of public transportation, while providing a framework for measuring transit availability and quality of service from the passenger's standpoint. Attachment A provides the Table of Contents for the document.

BOARD ACTION: **Approved as Recommended** [] **Other** []
 Approved with Modification(s) []

[To be filled in by District Secretary after Board/Committee Meeting]

The above order was passed on _____, 2005.

Rose Martinez, District Secretary
By _____

GM Memo No. 05-022

Subject: Timeline for review of TCRP Transit Capacity and Standards Manual

Date: February 2, 2005

Page 2 of 3

The manual is a useful reference for transit operations and bus operations. All facets of service delivery are discussed, including frequency standards, load factors, reliability, safety, appearance and cost. Capital elements of service quality are also addressed, such as availability of bus stops, bus preferential treatments, grade-separated facilities, and bus lanes. Operational considerations such as “skip stop operations” and demand responsive transportation are covered as well.

The manual is divided into nine parts. Several chapters simply provide an overview of concepts and definitions, while other chapters have more relevant application to the District. As such, staff recommends that the District focus on the areas that may provide direction on evaluating and improving service quality. Those sections are: Part 3--Quality of Service; Part 4—Bus Transit Capacity; and Part 7—Stop, Station and Terminal Capacity.

Staff has completed a preliminary review of the document to determine the timeline for presenting the Chapters to the Board along with any staff recommendations that may arise out of the material in the manual.

The timeline below presents an estimate for what staff will present to the Board over the next year:

Part 3: Quality of Service

March 2005--Chapter 1: Overview

April 2005—Chapter 1: Transit Performance Measures

May 2005— Chapter 1: Transit Trip Decision-Making Process

June 2005—Chapter 2: Quality of Service Factors: Availability Factors

July 2005-- Chapter 2: Comfort and Convenience Factors

August 2005-- Chapter 2: Measuring Quality of Service

September 2005—Chapter 2: Quality of Service Framework Development

October 2005—Chapter 3: Fixed Route Transit Service Measures: Availability—Transit Stops

November 2005—Chapter 3: Availability—Route Segments/Corridors

December 2005—Chapter 3 Availability--System

Prior Relevant Board Actions/Policies:

GM 04-361: Overview of TCRP Manual

GM Memo No. 05-022

Subject: Timeline for review of TCRP Transit Capacity and Standards Manual

Date: February 2, 2005

Page 3 of 3

Attachments:

Attachment A: Transit Capacity and Quality of Service Manual Table of Contents

**Approved by: Rick Fernandez, General Manager
Nancy Skowbo, Deputy General Manager Service Development**

Prepared by: Tina Spencer, Long Range Planning Manager

Date Prepared: January 25, 2005

CONTENTS

Part 1: Introduction and Concepts

CHAPTER 1. INTRODUCTION	1-1
Purpose of the Manual.....	1-1
Scope of the Manual.....	1-1
Use of the Manual	1-2
Measurement Units.....	1-2
North American and International Applications	1-2
TCQSM Media	1-3
Calculation Software.....	1-3
Other Reference Material on the CD-ROM.....	1-3
Typographic Conventions.....	1-3
What’s New in the Second Edition	1-4
Part 1: Introduction and Concepts	1-4
Part 2: Transit in North America	1-4
Part 3: Quality of Service	1-4
Part 4: Bus Transit Capacity	1-4
Part 5: Rail Transit Capacity.....	1-4
Part 6: Ferry Capacity.....	1-5
Part 7: Stop, Station, and Terminal Capacity	1-5
Part 8: Glossary	1-5
Part 9: Index.....	1-5
Future Updates.....	1-5
CHAPTER 2. QUALITY OF SERVICE CONCEPTS	1-7
Introduction	1-7
Transit Performance Measurement.....	1-7
Transit Availability.....	1-8
Transit Comfort and Convenience.....	1-8
Quality of Service Framework.....	1-9
Quality of Service Relationships.....	1-10
Capacity and Speed.....	1-10
Ridership.....	1-11
CHAPTER 3. CAPACITY CONCEPTS.....	1-13
Introduction	1-13
Capacity Defined.....	1-14
Capacity Relationships	1-14
Person Capacity	1-16
Vehicle Capacity	1-17

Transit Capacity Factors	1-18
Dwell Time	1-18
Right-of-Way Characteristics	1-19
Vehicle Characteristics	1-19
Loading Diversity	1-19
Economic Constraints	1-20
Agency Policies	1-20
Modal Capacities	1-20
CHAPTER 4. REFERENCES.....	1-23

Part 2: Transit in North America

CHAPTER 1. INTRODUCTION	2-1
Overview	2-1
Role of Transit	2-1
Dominance of Large Systems	2-2
Statistics	2-3
CHAPTER 2. BUS TRANSIT	2-5
Overview	2-5
Service Types	2-5
Fixed-Route	2-5
Demand-Responsive	2-5
Deviated Fixed-Route	2-7
Rural and Intercity	2-7
Other Modes	2-7
Operating Environments	2-7
Segregated Right-of-Way	2-8
High-Occupancy Vehicle (HOV) Lanes	2-9
Arterial Street Bus Lanes	2-9
Mixed Traffic	2-10
Vehicle Types	2-11
Observed Bus and Passenger Flows	2-13
Streets and Highways	2-13
Terminals	2-14
Bus Priority Treatments	2-14
Bus Rapid Transit	2-15
Description	2-15
Applications	2-16

CHAPTER 3. RAIL TRANSIT.....	2-17
Overview	2-17
Operating Environments	2-18
Exclusive Right-of-Way	2-18
Segregated Right-of-Way	2-18
Shared Right-of-Way.....	2-18
Rail Modes.....	2-18
Heavy Rail	2-18
Light Rail Transit	2-21
Commuter Rail.....	2-24
Automated Guideway Transit (AGT).....	2-27
Monorail	2-29
Funiculars, Inclines, and Elevators.....	2-30
Aerial Ropeways.....	2-32
Cable Cars.....	2-35
CHAPTER 4. FERRY TRANSIT.....	2-37
Overview	2-37
Service and Vessel Types.....	2-37
Urban Services	2-38
Coastal Services	2-38
Rural Services.....	2-38
Vessel Types	2-38
Ridership	2-40
CHAPTER 5. STOPS, STATIONS, AND TERMINALS	2-41
Overview	2-41
Transit Stop Types.....	2-41
Bus Stops.....	2-42
Transit Stations	2-42
Transit Centers.....	2-42
Intermodal Terminals	2-42
CHAPTER 6. REFERENCES.....	2-43

Part 3: Quality of Service

CHAPTER 1. QUALITY OF SERVICE FUNDAMENTALS	3-1
Overview	3-1
Definitions	3-1
Levels of Service	3-2
Level of Service Framework.....	3-2
Transit Performance Measures	3-3
Transit Trip Decision-Making Process.....	3-6
Availability	3-6
Comfort and Convenience.....	3-6
Summary	3-8
CHAPTER 2. QUALITY OF SERVICE FACTORS	3-9
Introduction	3-9
Availability Factors	3-9
Service Coverage	3-9
Scheduling.....	3-16
Capacity	3-16
Information.....	3-17
Comfort and Convenience Factors.....	3-18
Passenger Loads	3-18
Reliability.....	3-18
Travel Time.....	3-19
Safety and Security	3-20
Cost.....	3-21
Appearance and Comfort	3-21
Measuring Quality of Service	3-22
Quantitative Measures.....	3-22
Qualitative Measures	3-23
Quality of Service Framework Development	3-26
Service Measure Selection	3-26
Transit System Size Considerations.....	3-27
CHAPTER 3. FIXED-ROUTE TRANSIT SERVICE MEASURES.....	3-29
Introduction	3-29
Availability – Transit Stops.....	3-29
Other Measures.....	3-30
Availability – Route Segments/Corridors	3-31
Example Calculations.....	3-32
Other Measures.....	3-32
Availability – System	3-32

Planning Methodology	3-32
Detailed Methodology	3-37
Guidelines for Assessing Park-and-Ride Service Coverage	3-43
Comfort and Convenience – Transit Stops.....	3-43
Other Measures.....	3-45
Comfort and Convenience – Route Segments/Corridors.....	3-45
On-Time Performance.....	3-46
Headway Adherence.....	3-47
Example Calculations.....	3-48
Other Measures.....	3-48
Comfort and Convenience – System.....	3-49
Example Calculations.....	3-50
Other Measures.....	3-51
CHAPTER 4. DEMAND-RESPONSIVE TRANSIT SERVICE MEASURES	3-53
Introduction	3-53
Availability – Response Time	3-53
Availability – Service Span.....	3-54
Comfort and Convenience – Reliability.....	3-56
On-Time Performance.....	3-56
Trips Not Served: Trips Denied and Missed Trips	3-57
Comfort and Convenience – Travel Time	3-58
DRT-Auto Travel Time	3-59
CHAPTER 5. REFERENCES.....	3-61
CHAPTER 6. EXAMPLE PROBLEMS	3-65
APPENDIX A: EXHIBITS IN METRIC UNITS	3-93

Part 4: Bus Transit Capacity

CHAPTER 1. BUS CAPACITY FUNDAMENTALS.....	4-1
Overview	4-1
Capacity Calculation Process.....	4-1
Loading Areas.....	4-2
Bus Stops.....	4-2
Bus Facilities.....	4-3
Person Capacity	4-3
Loading Area Bus Capacity	4-3
Dwell Time	4-3
Clearance Time	4-7
Dwell Time Variability.....	4-8

Traffic Signal Timing.....	4-10
Calculation Procedure.....	4-10
Bus Stop Vehicle Capacity.....	4-11
Design and Location Considerations.....	4-11
Bus Stop Effectiveness.....	4-12
Calculation Procedure.....	4-15
Bus Facility Concepts.....	4-16
Person Capacity.....	4-16
Loading Diversity.....	4-16
Operator Policy.....	4-17
CHAPTER 2. BUS PREFERENTIAL TREATMENTS.....	4-19
Introduction.....	4-19
Bus Preferential Treatment Uses.....	4-19
Person Delay Concepts.....	4-20
Busways and Freeway HOV Lanes.....	4-20
Operational Overview.....	4-21
HOV Lanes.....	4-23
Freeway Ramp Queue Bypasses.....	4-23
Arterial Street Bus Lanes.....	4-24
Traffic Signal Priority.....	4-25
Overview.....	4-25
Notes on Application.....	4-26
Site-Specific Priority Treatments.....	4-27
Queue Jumps.....	4-27
Boarding Islands.....	4-28
Curb Extensions.....	4-29
Yield to Bus Laws.....	4-30
Parking Restrictions.....	4-31
Turn Restriction Exemptions.....	4-31
Transit Operating Measures.....	4-31
Bus Stop Relocation.....	4-31
Bus Stop Consolidation.....	4-32
Skip-Stop Operation.....	4-32
Platooning.....	4-33
Design Standards.....	4-33
Summary.....	4-33
CHAPTER 3. PLANNING APPLICATIONS.....	4-35
Introduction.....	4-35
Transit Preferential Treatments.....	4-35
Uninterrupted Flow Facilities.....	4-35

Interrupted Flow Facilities	4-37
Bus Stop and Facility Capacity	4-38
Bus Volume and Capacity Relationships	4-38
Busways	4-40
Arterial Street Bus Lanes	4-40
Mixed Traffic Operations	4-41
Bus Stops and Loading Areas	4-41
Factors Influencing Bus and Person Capacity	4-41
CHAPTER 4. GRADE-SEPARATED FACILITIES	4-43
Introduction	4-43
Bus Capacity.....	4-43
Busways	4-43
Freeway HOV Lanes	4-45
Bus Speeds.....	4-46
CHAPTER 5. ARTERIAL STREET BUS LANES	4-47
Introduction	4-47
Bus Lane Types.....	4-47
Bus Capacity.....	4-47
Right-Turning Traffic Delays	4-48
Skip-Stop Operations	4-49
Capacity Calculation Procedure	4-50
Bus Speeds.....	4-52
Arterial Streets	4-52
CHAPTER 6. MIXED TRAFFIC.....	4-57
Introduction	4-57
Types Of Bus Operations.....	4-57
Bus Capacity.....	4-57
Bus Speeds.....	4-59
CHAPTER 7. DEMAND-RESPONSIVE TRANSPORTATION.....	4-61
Introduction	4-61
Service Characteristics	4-61
Vehicle Types	4-62
DRT Capacity	4-62
Capacity Factors.....	4-62
Capacity Calculation Procedure	4-63
CHAPTER 8. REFERENCES.....	4-65
CHAPTER 9. EXAMPLE PROBLEMS	4-69

APPENDIX A: EXHIBITS IN METRIC UNITS 4-91

APPENDIX B: DWELL TIME DATA COLLECTION PROCEDURE 4-93

APPENDIX C: BUS EFFECTS ON ADJACENT LANE VEHICLE CAPACITY 4-97

APPENDIX D: PLANNING-LEVEL CAPACITY GRAPHS 4-99

APPENDIX E: EFFECTS OF BUS BUNCHING ON PERSON CAPACITY..... 4-109

Part 5: Rail Transit Capacity

CHAPTER 1. RAIL CAPACITY FUNDAMENTALS..... 5-1

Overview 5-1

Line Capacity 5-2

 Train Control and Signaling..... 5-2

 Dwell Time 5-3

 Operating Margin..... 5-3

 Turnbacks 5-3

 Junctions 5-4

 Mode-Specific Issues 5-5

Person Capacity 5-5

 Loading Diversity 5-5

 Number of Cars 5-7

 Number of Trains 5-9

 Calculation Procedure..... 5-9

CHAPTER 2. TRAIN CONTROL AND SIGNALING 5-11

Introduction 5-11

Fixed-Block Systems..... 5-11

Cab Signaling 5-12

Moving-Block Systems..... 5-12

 Safety Issues 5-13

Hybrid Systems 5-13

Automatic Train Operation..... 5-13

Automatic Train Supervision..... 5-14

Train Throughput..... 5-14

 Station Close-In Time 5-14

 Turnbacks 5-15

 Junctions 5-17

CHAPTER 3. STATION DWELL TIMES.....	5-19
Introduction	5-19
Dwell Time Components.....	5-19
Doorway Flow Rates.....	5-19
Effect of Door Width on Passenger Flow Times.....	5-23
Effect of Number of Door Channels on Dwell Times.....	5-23
Estimating Dwell Times	5-23
CHAPTER 4. PASSENGER LOADING LEVELS.....	5-25
Introduction	5-25
Loading Standards	5-25
Space Requirements	5-26
Vehicle-Specific Calculations.....	5-26
Default Method.....	5-29
Length.....	5-29
Summary	5-30
CHAPTER 5. OPERATING ISSUES.....	5-31
Introduction	5-31
Operating Margins	5-31
Estimating Operating Margins	5-34
Skip-Stop and Express Operation	5-35
Passenger-Actuated Doors.....	5-35
Other Station Constraints.....	5-36
Wheelchair Accommodations.....	5-37
Wheelchair Boarding Methods.....	5-38
System Design.....	5-45
Disabled Trains	5-45
Track Maintenance	5-46
Special Events.....	5-47
CHAPTER 6. PLANNING APPLICATIONS	5-49
Introduction	5-49
Growth and Capacity.....	5-49
Planning Assumptions.....	5-49
Capacity Analysis Categories	5-50
Grade-Separated Rail Capacity	5-50
Systems Designed for Economy	5-50
Systems Designed for Maximum Capacity.....	5-51
Light Rail Capacity.....	5-53
Single Track.....	5-53
Exclusive Lane Operation.....	5-54
Private Right-of-Way with Grade Crossings	5-54

Commuter Rail Capacity	5-55
Automated Guideway Transit Capacity	5-55
Ropeway Capacity.....	5-55
Reversible System Capacity	5-55
Continuously Circulating System Capacity	5-56
CHAPTER 7. GRADE-SEPARATED SYSTEMS	5-57
Introduction	5-57
Determining the Weakest Capacity Link	5-57
Grade-Separated Capacity Calculation Procedure	5-58
Step 1: Determining the Maximum Load Point Station.....	5-58
Step 2: Determining the Control System’s Minimum Train Separation.....	5-59
Step 3: Determining the Dwell Time.....	5-64
Step 4: Selecting an Operating Margin	5-66
Step 5: Selecting a Passenger Loading Level.....	5-67
Step 6: Determining an Appropriate Peak Hour Factor	5-68
Step 7: Putting It All Together	5-69
Person Capacity	5-69
CHAPTER 8. LIGHT RAIL CAPACITY	5-71
Introduction	5-71
Determining the Weakest Link.....	5-71
Other Capacity Issues	5-71
Single Track.....	5-72
Calculating Single-Track Headway Restrictions	5-72
Signaled Sections	5-74
On-Street Operation	5-74
Determining On-Street Capacity	5-75
Private Right-of-Way with Grade Crossings	5-76
Signal Pre-emption.....	5-76
Grade Crossings and Station Dwell Times	5-77
Train Throughput.....	5-78
Person Capacity	5-79
CHAPTER 9. COMMUTER RAIL CAPACITY.....	5-81
Introduction	5-81
Track Ownership and Usage	5-81
Train Throughput.....	5-83
Line Capacity Range	5-83
Station Constraints	5-84
Station Dwells	5-84
Means of Increasing Line Capacity	5-85

Double Tracking	5-85
Adding and Lengthening Sidings	5-86
Providing Higher-Speed Siding Entries and Exits	5-86
Train Control System Improvements.....	5-86
Infrastructure Improvements.....	5-86
Commuter Rail Operating Speeds	5-87
Person Capacity	5-88
CHAPTER 10. AUTOMATED GUIDEWAY TRANSIT CAPACITY.....	5-91
Introduction	5-91
Train Control Separation.....	5-91
Passenger Flow Rates and Dwells.....	5-92
Loading Levels.....	5-93
Off-Line Stations.....	5-93
CHAPTER 11. ROPEWAY CAPACITY	5-95
Introduction	5-95
Reversible System Capacity	5-95
Continuously Circulating System Capacity.....	5-96
Person Capacity	5-97
CHAPTER 12. REFERENCES	5-99
CHAPTER 13. EXAMPLE PROBLEMS	5-101
APPENDIX A: EXHIBITS IN METRIC UNITS	5-117
APPENDIX B: RAIL ROUTE CHARACTERISTICS	5-123
Part 6: Ferry Capacity	
CHAPTER 1. FERRY CAPACITY.....	6-1
Introduction	6-1
Ferry Facilities and Service.....	6-1
Ferry Service.....	6-1
Vessel Type.....	6-2
Docks and Loading Facilities	6-4
Vessel Capacity	6-9
Berth Capacity.....	6-10
Dock Capacity	6-17
Passenger and Auto Capacity	6-17
CHAPTER 2. REFERENCES.....	6-19
CHAPTER 3. EXAMPLE PROBLEMS	6-21

Part 7: Stop, Station, and Terminal Capacity

CHAPTER 1. INTRODUCTION	7-1
CHAPTER 2. STATION TYPES AND CONFIGURATIONS	7-3
Overview	7-3
Bus Stops.....	7-3
Transit Centers.....	7-3
Busway Stations.....	7-4
Light Rail Stations	7-4
Heavy Rail Stations	7-4
Commuter Rail Stations.....	7-4
Ferry Docks and Terminals	7-5
Intermodal Terminals	7-5
CHAPTER 3. PASSENGER CIRCULATION AND LEVEL OF SERVICE	7-7
Pedestrian Circulation Concepts	7-7
Pedestrian Capacity Terminology	7-7
Principles of Pedestrian Flow	7-8
Pedestrian Level of Service.....	7-8
Circulation on Walkways	7-8
Speed	7-9
Density	7-9
Effective Walkway Width.....	7-9
Levels of Service for Walkways	7-10
Circulation on Stairways	7-12
Levels of Service for Stairways	7-13
Occupancy in Queuing and Waiting Areas	7-14
Levels of Service for Queuing and Waiting Areas	7-14
Multi-Activity Passenger Circulation Areas	7-15
Access for Persons with Disabilities	7-16
Emergency Evacuation	7-17
Security	7-18
Clarity of Station Layout and Wayfinding.....	7-18
Comprehensive Analysis of Passenger Circulation.....	7-19
Pedestrian System Requirements	7-19
Comprehensive Passenger Circulation Analysis	7-20
Manual Method/Input to Simulation Models.....	7-20
CHAPTER 4. STATION ELEMENTS AND THEIR CAPACITIES.....	7-23
On-Street Bus Stops.....	7-23
Design Factors.....	7-23
Waiting Area Level of Service.....	7-23

Evaluation Procedures	7-23
Off-Street Bus Stops	7-24
Design Factors	7-24
Waiting Area Level of Service	7-25
Evaluation Procedures	7-25
Station Platforms	7-26
Design Factors	7-26
Waiting Area Level of Service	7-26
Evaluation Procedures	7-27
Shelters, Waiting Rooms, and Seating	7-28
Design Factors	7-28
Shelter or Waiting Room Level of Service	7-28
Evaluation Procedures	7-29
Walkways	7-29
Design Factors	7-29
Evaluation Procedures	7-30
Doorways	7-31
Design Factors	7-31
Doorway Level of Service	7-31
Evaluation Procedures	7-31
Stairways	7-32
Design Factors	7-32
Evaluation Procedures	7-33
Escalators	7-34
Design Factors	7-34
Escalator Capacity	7-35
Evaluation Procedures	7-36
Moving Walkways	7-37
Design Factors	7-37
Moving Walkway Capacity	7-37
Evaluation Procedures	7-38
Elevators and Lifts	7-38
Design Factors	7-38
Elevator Level of Service	7-39
Evaluation Procedures	7-39
Ramps	7-40
Design Factors	7-40
Ramp Level of Service	7-40
Evaluation Procedures	7-40
Fare Control Barriers, Gates, and Turnstiles	7-41
Design Factors	7-41

Fare Gate Capacity	7-42
Evaluation Procedures	7-42
Ticket Machines	7-43
Design Factors.....	7-43
Ticket Machine Level of Service	7-43
Evaluation Procedures	7-44
Signage and Passenger Communication Systems.....	7-44
Signage and Information Displays	7-44
Public Address Systems.....	7-45
Real-Time Passenger Information Systems.....	7-45
Passenger Amenities	7-45
Bicycle Storage	7-47
Park-and-Ride Facilities.....	7-47
Kiss-and-Ride Facilities	7-48
CHAPTER 5. REFERENCES.....	7-49
CHAPTER 6. EXAMPLE PROBLEMS	7-51
APPENDIX A: EXHIBITS IN METRIC UNITS	7-67
Part 8: Glossary	
GLOSSARY	8-1
LIST OF SYMBOLS	8-55
Part 9: Index	
INDEX	9-1