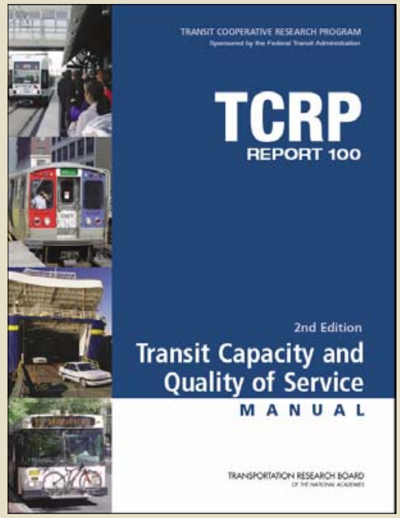
Rail Transit Capacity TCQSM, 2nd Edition

Foster Nichols
Parsons Brinckerhoff



Presentation Overview

- Brief introduction to the project
- Line Capacity
- Person Capacity
- Grade Separated Systems
- Light Rail Capacity
- Commuter Rail Capacity
- Automated Guideway Transit Capacity
- Ropeway Capacity
- Questions to think about

Project Overview

- Obtain user feedback on the TCQSM 2nd Edition (2003)
- Recommend additions, revisions, format
- Conduct gap-filling research
- Prepare TCQSM 3rd Edition
- Prepare information program

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

TCQSM Webinar Series Objectives

- Provide background on TCQSM material for focus group and online survey participants
- Expand industry's awareness of the manual and its potential uses
- Lay groundwork for updated training material when the new manual is published (2013)

Kittelson & Associates, Inc. Transportation Engineering/Planning · Parsons Brinckerhoff · KFH Group · Texas Transportation Institute · ARUP

Webinar Series Topics

- Overview of the TCQSM 2nd Edition
- Fixed Route Quality of Service
- Bus Transit Capacity
- Rail Transit Capacity
- Ferry Transit Capacity
- Stop, Station, and Terminal Capacity
- Demand Response Capacity and Quality of Service

www.tcqsm.org

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

Factors that determine rail capacity

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Turnbacks
  - Junctions
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Kittelson & Associates, Inc. Transportation Engineering/Planning · Parsons Brinckerhoff · KFH Group · Texas Transportation Institute · ARUP

- **Line Capacity**
  - **Dwell Time**
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Dwell Time

How long a train is stopped to serve passengers at a station. Station dwell times are the major component of headways at short frequencies.

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - **Dwell Time**
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Dwell Time

Main constituents of dwell time are:

- Passenger flow time at the busiest door,
- Remaining (unused) door open time, and
- Waiting to depart time (with doors closed)

- **Line Capacity**
  - Dwell Time
  - **Signal System**
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Signal System
Determines minimum spacing between trains

- Fixed Block
- Cab Signaling
- Moving Block

- **Line Capacity**
  - Dwell Time
  - **Signal System**
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Signal System
Determines minimum spacing between trains

- **Fixed Block**
  - Provides a coarse indication of train location
  - A minimum of two empty blocks are required between trains for a two-aspect system
  - Conventional train control systems can support a throughput of 30 trains/track/hour

- **Line Capacity**
  - Dwell Time
  - **Signal System**
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Signal System

Determines minimum spacing between trains

- **Cab Signaling**
  - Cab signaling sets authorized, safe train speeds
  - Authorized speeds displayed in driver's cab
  - Problems with signal visibility reduced or eliminated
  - A typical selection of reference speeds would be 50, 40, 30, 20, and 0 mph

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - Dwell Time
  - **Signal System**
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Signal System

Determines minimum spacing between trains

- **Moving Block**
  - Also called *transmission-based* or *communication-based* signaling systems
  - Requires continuous or frequent two-way communication with each train, and precise knowledge of a train's location, speed, and length, and of fixed details of the line—curves, grades, interlockings, and stations
  - Computer calculates the next stopping point of each train—the target point—and commands the train to brake, accelerate, or coast accordingly

KITTELSON & ASSOCIATES, INC. TRANSPORTATION ENGINEERING/PLANNING PARSONS BRINCKERHOFF KFH GROUP Texas Transportation Institute ARUP

- **Line Capacity**
  - Dwell Time
  - Signal System
  - **Operating Margin**
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Operating Margin

Amount of time beyond average dwell time before the following train is delayed

TCQSM recommends 2 standard deviations of dwell time, or 15-25 sec for planning purposes

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - **Minimum Headway**
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Minimum Headway

Control station dwell time, signal system headway, and operating margin will control the minimum headway - Assumes no sharp curves or steep grades to slow trains entering the station with the longest dwell

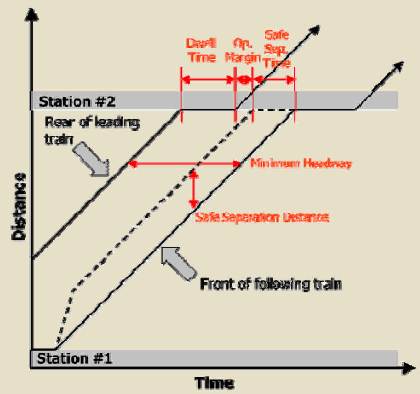
Other factors may also need to be considered:

- Junctions
- Turnbacks
- Power supply constraints

Kittelson & Associates, Inc. Transportation Engineering/Planning | Parsons Brinckerhoff | KFH Group | Texas Transportation Institute | ARUP

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - **Minimum Headway**
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

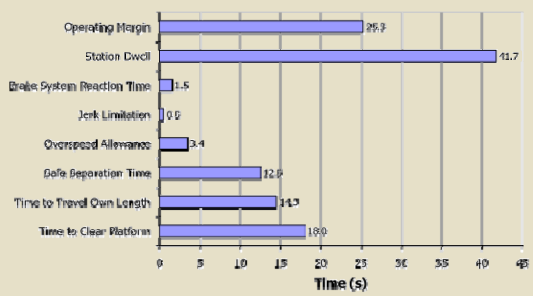
Minimum Headway



NOTE: Acceleration and braking curves omitted for clarity.

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - **Minimum Headway**
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Minimum Headway



NOTE: Based on a heavy rail system operating at 120-s headways, with cab signaling.

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Line Capacity

Line capacity (trains/h) = 3600 s/h / minimum headway (s/train)

Typical line capacity values:

- Light rail, designed for economy, rather than maximum capacity: **20** trains per hour
- Fixed-block (red-yellow-green): **30** trains per hour
- Cab control, 8-car trains: **30-34** trains/hour
- Moving block, 8-car trains: **35-42** trains/hour

All values assume that the critical dwell time is under 60 seconds & there are no line merges

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - **Junctions**
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Flat Junctions

- Tracks cross at grade
- May support 2-min headways, but train interference results
- Grade-separate at 150- to 180-second headways if possible

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - **Junctions**
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Flat Junctions

$$h_j = h_l + \sqrt{\frac{2(L_t + 2 f_{sa} d_{ts})}{a}} + \frac{v_l}{a+d} + t_s + t_{om}$$

where: *[typical heavy rail values shown in brackets]*

h_j= limiting headway at junction (s);
h_l= line headway (s); *[32 s]*
L_t= train length (ft, m); *[650 ft, 200 m]*
d_{ts}= track separation (ft, m); *[33 ft, 10 m]*
f_{sa}= switch angle factor:
— 5.77 for #6 turnout,
— 6.41 for #8 turnout, and
— 9.62 for #10 turnout;
a= initial service acceleration rate (ft/s^2 ,m/s^2); *[4.3 ft/s^2 ,1.3 m/s^2]*
d= service deceleration rate (ft/s^2, m/s^2); *[4.3 ft/s^2 ,1.3 m/s^2]*
v_l= line speed (mph, km/h); *[60 mph = 91 ft/s, 100 km/h = 27.8 m/s]*
t_s= switch throw and lock time (s); and *[6 s]*
t_{om}= operating margin time (s).

Turnout # = # of feet moved longitudinally per foot of separation between the tracks—lower numbers permit higher operating speeds

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - **Junctions**
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Line Merges

Even with flying junctions, line merges can create operational problems:

- Train on one line arrives late to fill its slot, delaying the next train on the other line
- May not be able to sustain quite as much capacity as a similar line that has no line merges

Kittelson & Associates, Inc. Transportation Engineering/Planning · Parsons Brinckerhoff · KFH Group · Texas Transportation Institute · ARUP

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - **Turnbacks**
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Turnbacks

Typically handle two trains at once in high-capacity situations

Time in turnback cannot exceed twice the line headway without creating a capacity constraint

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - **Turnbacks**
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Turnbacks

Time in turnback includes:

- Passenger service time
- Time for driver to switch ends of the train and perform inspections (can occur during passenger service time)
- Time to clear crossover prior to turnback
- Operating margin

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - **Turnbacks**
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Turnbacks

Methods for improving turnback time:

- Substitute a new driver
- Crossovers in front of and beyond terminal station
- Multiple drop-off platforms
- Turning loop

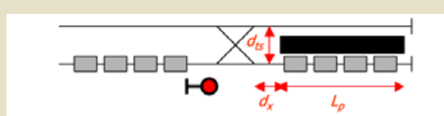
- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - **Turnbacks**
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Turnbacks

$$t_l \leq 2\left(h - t_s - \sqrt{\frac{2(L_p + d_x + f_{sa} d_{ts})}{a + d}} - \sqrt{\frac{(L_p + d_x + f_{sa} d_{ts})}{2a}}\right)$$

where: *[typical heavy rail values shown in brackets]*

t_l= terminal layover time (s);
h= train headway (s); *[120 s]*
t_s= switch throw and lock time (s); *[6 s]*
L_p= platform length (ft, m); *[660 ft, 200 m]*
d_x= distance from cross-over to platform (ft, m); *[65 ft, 20 m]*
d_{ts}= track separation (ft, m), platform width + 5.25 ft (1.6 m); *[33 ft, 10 m]*
f_{sa}= switch angle factor (see also):
— 5.77 for #6 turnout,
— 6.41 for #8 turnout, and
— 9.62 for #10 turnout;
a= initial service acceleration rate (ft/s^2, m/s^2); and *[4.3 ft/s^2, 1.3 m/s^2]*
d= service deceleration rate (ft/s^2, m/s^2). *[4.3 ft/s^2, 1.3 m/s^2]*



- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - **Power Supply**
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Power Supply

Power system may limit number of trains on a given track section - unique to each situation

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Person Capacity

Kittelson & Associates, Inc. Transportation Engineering/Planning | Parsons Brinckerhoff | KFH Group | Texas Transportation Institute | ARUP

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - Loading Diversity

Person Capacity

Generally Person Capacity =
Trains per hour * cars per train * maximum schedule load per train * PHF (Peak Hour Factor)

Potential constraints include:

- Platform or street block lengths
- Supply of cars

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - **Passenger Loading Levels**
  - Peak Hour Factor
  - Loading Diversity

Passenger Loading Levels

Loading levels vary widely by transit mode and system.

System (City)	Passenger Space (based on gross floor space) (ft^2/p)	(m^2/p)
NYCT (New York)	4.0 into CBD	0.38 into CBD
CTA (Chicago)	7.0 into CBD	0.67 into CBD
SEPTA (Philadelphia)	8.0 Into CBD	0.77 Into CBD
MBTA (Boston)	5.0 Into CBD	0.50 Into CBD
BART (San Francisco)	5.75-9.0	0.53-0.83
WMATA (Washington)	5.0-12.0	0.50-1.11
MARTA (Atlanta)	6.75-7.5	0.63-0.71
TTC (Toronto)	4.5-6.0	0.42-0.56
STM (Montréal)	3.4-4.0	0.31-0.38

CBD: central business district

Passenger Space on Selected North American Heavy Rail Systems During Peak 15 Minutes (1995)

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - **Passenger Loading Levels**
  - Peak Hour Factor
  - Loading Diversity

Passenger Loading Levels

$$C_v = \left[\frac{(L_c - 0.5L_a)W_c - 0.5D_n W_s D_w}{S_{sp}}\right] + N\left[\left(1 - \frac{S_a}{S_{sp}}\right)\left(\frac{L_c - L_a - D_n(D_w + 2S_b)}{S_w}\right)\right]$$

where:

C_c= car capacity—peak 15 minutes (p/car);
L_c= car interior length (ft, m);
L_a= articulation length for light rail (ft, m);
W_s= stepwell width (certain light rail only) (ft, m);
W_c= car interior width (ft, m);
S_{sp}= space per standing passenger (ft 2 , m 2):
2.15 ft 2 (0.2 m 2)—crush load,
3.2 ft 2 (0.3 m 2)—maximum schedule load, and
5.4 ft 2 (0.5 m 2)—comfortable standing load;
N= seating arrangement:
2 for longitudinal seating,
3 for 2+1 transverse seating,
4 for 2+2 transverse seating, and
5 for 2+3 transverse seating; 6
S_a= area of single seat (ft 2 , m 2):
5.4 ft 2 (0.5 m 2) for transverse, and
4.3 ft 2 (0.4 m 2) for longitudinal;
D_n= number of doorways;
D_w= doorway width (ft, m);
S_b= single setback allowance (ft, m):
0.67 ft (0.2 m)— or less; and
S_w= seat pitch (ft, m):
2.25 ft (0.69 m) for transverse, .42 ft (0.43 m) for longitudinal

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - **Peak Hour Factor**
  - Loading Diversity

Peak Hour Factor

Default Factors:

- Heavy rail: 0.80
- Light rail: 0.75
- Commuter rail: 0.60

TCQSM tabulates PHFs observed on various North American rail systems in mid-1990s

- **Line Capacity**
  - Dwell Time
  - Signal System
  - Operating Margin
  - Minimum Headway
  - Junctions
  - Turnbacks
  - Power Supply
- **Person Capacity**
  - Passenger Loading Levels
  - Peak Hour Factor
  - **Loading Diversity**

Loading Diversity

Passengers do not arrive at even rate during hour

Passengers may not be spread out evenly among all cars of train due to:

- Distribution of station entrance locations along line
- Locations of connections at transfer stations

Not all capacity will be used

Grade Separated Systems

Options include:

- Elevated
- Tunnel
- At grade/in trench

Provides fast operations

AGT always, heavy rail (metro) almost always grade-separated. Commuter & light rail frequently also have grade-separated sections.

Grade Separated Systems

In all but the most exceptional situations, the capacity limitation will be the **close-in, dwell, and operating margin** time at the maximum load point station. The capacity procedure requires that the following values be calculated:

1. The close-in time at the maximum load point station,
2. The dwell time at this station,
3. A suitable operating margin,
4. The peak 15-minute train passenger load,
5. The peak hour factor to translate from the peak 15 minutes to peak hour.

Grade Separated Systems

$$P = TLP_m(PHF) = \frac{3{,}600 LP_m(PHF)}{t_{cs} + t_d + t_{om}}$$

where:

P=	**person capacity (p/h);**
T =	line capacity (trains/h);
L=	train length (ft, m);
P_m=	linear passenger loading level (p/ft length, p/m length);
PHF=	peak hour factor;
t_{cs}=	minimum train control separation (s);
t_d=	dwell time at critical station (s); and
t_{om}=	operating margin (s).

Light Rail Capacity

Light Rail Capacity Procedure

Find the weakest link

In order of importance, these are typically:

•Single-track two-way sections

•Signaled sections w/grade crossings

•Signaled sections, grade separated

•On-street sections

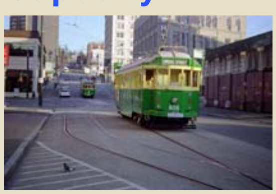
Also check:

•Flat junctions

•Turnbacks

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

Light Rail Capacity



Single-Track Two-Way Operation

Sections longer than 1/4 mile are potentially the greatest capacity constraint

Uses
•Cost-saving measure
•Right-of-way constraints

Considerations
•Scheduling
•Location of passing sections
•Changing headways may mean relocating passing sections

Kittelson & Associates, Inc. Transportation Engineering/Planning · Parsons Brinckerhoff · KFH Group · Texas Transportation Institute · ARUP

Light Rail Capacity

Single-Track Capacity

When there **are no stations** within the single-track section, the minimum headway is twice the sum of:

- The time required for a train to traverse the single-track section
- An operating margin
- Switch throw-and-lock time (default = 6 s)

Light Rail Capacity

Single-Track Capacity

When there **are stations** within the single-track section, the minimum headway is twice the sum of:

- The time required for a train to traverse the single-track section without stopping
- Dwell time at each station within the single-track section
- Acceleration/deceleration delay time
- An operating margin
- Switch throw-and-lock time (default = 6 s)

Light Rail Capacity

Exclusive Lane Operations

Traffic signals control minimum headway

Assumes dwell is shorter than traffic signal cycle length

Light Rail Capacity

Mixed Traffic

Traffic signal cycle length or critical station dwell time may control

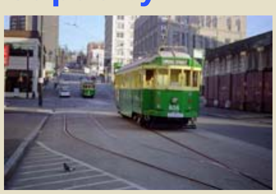
Light Rail Capacity

Mixed Traffic Capacity

Minimum headway is the larger of twice the traffic signal cycle length, or the capacity calculated using the bus loading area capacity formula

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

Light Rail Capacity



Private Right-of-Way with Grade Crossings & Street Median Running

Use grade-separated capacity procedure

May have added dwell (around 10s) at stations immediately before a grade crossing (Time to lower gates or pre-empt signal when train is ready to depart)

Commuter Rail Capacity

Simulation is often the only tool available for calculating commuter rail capacity.

Commuter rail capacity determination is inexact

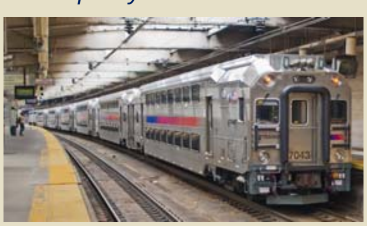
•Many commuter rail operators do not own the tracks they use; therefore the number of trains they can operate will depend on negotiations with the host railroad

•Performance of diesel locomotives used by U.S. commuter operators varies considerably

•The number of platforms available at terminal stations may constrain capacity

Commuter Rail Capacity

Simulation is often the only tool available for calculating commuter rail capacity.



Means of Expanding Capacity

•Double Tracking

•Adding and/or Lengthening Sidings

•Providing Higher Speed Siding Entries and Exits

•Trains Control System Improvements

•Infrastructure Improvements

Person Capacity

(trains per hour) x (seats per train) x 0.90

Automated Guideway Transit Capacity

AGT has a relatively low share of transit ridership – primarily used in institutional systems such as intra airport shuttles.

Generally, methodology for grade separated systems can be used to find capacity for AGT.

Nuances for AGT include:

- Doorway flow rates (airports)
- AGT loading levels tend to be atypical of transit overall
- Off-line stations

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

Ropeway Capacity

Ropeways in North America are more commonly used by private owners than by public transit agencies.

Two Primary Categories:

- Reversible Systems
- Continuously Circulating Systems

Kittelson & Associates, Inc. Transportation Engineering/Planning · Parsons Brinckerhoff · KFH Group · Texas Transportation Institute · ARUP

Ropeway Capacity

Directional Line Capacity of Reversible System

$$T = \frac{1{,}800 N_v}{(N_s t_d) + \frac{L_l}{v_l}}$$

where:

T=	**line capacity (trains/h, carriers/h);**
1,800=	number of seconds in an hour, divided by two;
N_v=	number of vehicles (1 or 2);
N_s=	number of stops per direction: 1—two-station system, 2—three-station system, with middle station exactly halfway, and 3—three-station system, with offset middle station;
t_d=	average dwell time (s);
L_l =	line length (ft, m); and
v_l =	average line speed (ft/s, m/s)

Ropeway Capacity

Continuously Circulating System Capacity

$$T = 3{,}600 \frac{v_l}{d_c}$$

where:

T =	**line capacity (trains/h, cars/h, carriers/h);**
v_l=	average line speed (ft/s, m/s); and
d_c=	average carrier/train/car spacing on the line (ft/carrier, m/carrier).

Ropeway Capacity

Person Capacity

$$P=TC_c(PHF)$$

where:

P=	**person capacity (p/h);**
T=	line capacity (carriers/h);
C_c=	carrier capacity (p/carrier); and
PHF=	peak hour factor.

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

Questions to Think About

Kittelson & Associates, Inc. Transportation Engineering/Planning · Parsons Brinckerhoff · KFH Group · Texas Transportation Institute · ARUP

Questions to Think About

- Can the use of simulation modeling help our understanding of rail transit capacity?
- Should station capacity be considered as a distinct element of system capacity?
- What are the operational differences between turnbacks at end point terminals vs. short term operations at intermediate stops?
- How do safety issues affect how we assess capacity?

Transit Capacity and Quality of Service Manual, 3rd Edition
Rail Transit Capacity TCQSM 2nd Edition

Questions to Think About

- How does shared use between commuter and traditional or high-speed intercity operations impact capacity? How about multiple types of commuter and/or regional transit on shared line? Peak-oriented vs bi-directional operations?
- What is the difference between theoretical and practical capacity?
- How does passenger distribution between cars relate to platform access/egress points?

Kittelson & Associates, Inc. Transportation Engineering/Planning · Parsons Brinckerhoff · KFH Group · Texas Transportation Institute · ARUP

Questions to Think About

- What are the design issues regarding ultimate system capacity vs. opening day capacity?
- What is the impact of track maintainence work on capacity and operations?
- How does joint LRT/BRT operations in a dedicated ROW impact capacity?
- What are the capacity impacts of maximum line speed, variable stopping patterns, overtakes at intermediate stations, junctions, power supply limitations, and overall network complexity?

We Want Your Input on the TCQSM!

- Take our online survey to help shape the 3rd Edition's content
- Stay involved with the project
  - Give us your e-mail address after completing the survey and we'll keep you informed of future opportunities to provide input
- Do you go to the Transportation Research Board's Annual Meeting?
  - Attend the meeting of the Transit Capacity and Quality of Service Committee (AP015)

www.tcqsm.org