TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Report 30

Transit Scheduling: Basic and Advanced Manuals

Transportation Research Board
National Research Council

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Report 30

Transit Scheduling: Basic and Advanced Manuals

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Nelson\Nygaard Consulting Associates

Subject Area
Planning and Administration
Public Transit

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY PRESS
Washington, D.C. 1998

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 Transit 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 Academy of Sciences, 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.

TCRP REPORT 30

Project A-11 FY'94
ISSN 1073-4872
ISBN 0-309-0-06262-4
Library of Congress Catalog Card No. 98-60091

Price $57.00

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The project that is the subject of this report was a part of the Transit Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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TRANSIT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

and can be ordered through the Internet at
http://www.nas.edu/trb/index.html

Printed in the United States of America

FOREWORD

By Staff
Transportation Research Board

This manual will be of interest to new transit schedulers, experienced schedulers, transit planners, operating staff, and others who need to be conversant with the scheduling process. The materials clearly describe all steps in the bus and light rail scheduling process.

Scheduling is a craft, whether executed manually or with computer assistance. New employees of transit scheduling departments need training in this craft to do their job, and experienced schedulers require retraining to fill gaps in their knowledge. The best known reference guide on this topic was issued in 1946; it does not reflect modern information technology or operating conditions. Therefore, a new transit scheduling manual, suitable for use in a training course, was needed by the transit industry.

Under TCRP Project A-11, *Transit Scheduling: A Manual with Materials*, research was undertaken by Transportation Management & Design of Solana Beach, California, to prepare a transit scheduling manual that incorporates modern training techniques for bus and light rail transit scheduling. The manual consists of two sections: a basic treatment and an advanced section. The basic-level section is in an instructional format designed primarily for novice schedulers and other transit staff. The advanced section covers more complex scheduling requirements. Each section may be used sequentially or independently and is designed to integrate with agency apprenticeship and on-the-job training.

To achieve the project objective of producing an updated transit scheduling manual, the researchers conducted a review of literature and existing practices to identify methods used to schedule transit vehicles and personnel; conducted site visits at a cross-section of transit agencies to establish the state of practice; prepared a glossary to define scheduling terminology and identify common synonyms; and developed a manual that outlines the steps in a model scheduling process. These steps include both manual and microcomputer applications using standard commercial spreadsheet software.

The basic-level training section was evaluated at two mid-sized transit systems and at one smaller midwest university. The advanced training section was evaluated at two larger, multimodal transit systems. The findings indicate that the content and design of the manual effectively and efficiently meet a need for practical, structured and documented transit scheduling training materials applicable to both transit and nontransit participants with varying degrees of transit experience and need.

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AUTHOR ACKNOWLEDGMENTS

The research reported herein was performed under TCRP Project A-11 by Transportation Management & Design (TMD) in association with Nelson\Nygaard Consulting Associates.

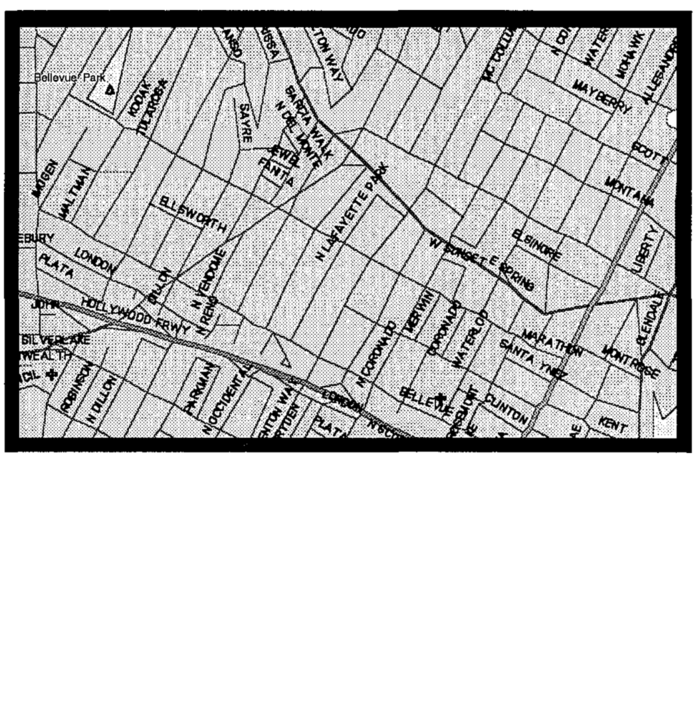
Randall Pine, Senior Associate at TMD was the Principal Investigator. James Niemeyer, also a Senior Associate at TMD, was the Co-Principal Investigator of this project. The work was done under the general supervision of Randall Pine and James Niemeyer. Other members of the research team included David Sharfarz, TMD Senior Researcher; Russell Chisholm, Senior Researcher and Senior Partner at TMD; Susan Law, Researcher at TMD; and Bonnie Nelson, Senior Researcher subcontracting from Nelson\Nygaard Consulting Associates. Mark Bergstrom, Senior Partner at TMD, acted as Administrative Officer.

TRANSIT SCHEDULING: BASIC MANUAL

CONTENTS

CHAPTER 1

SERVICE POLICIES
AND
SCHEDULE DEVELOPMENT



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STUDY OBJECTIVES

1) Remember that the development of service schedules is heavily influenced by organizational service standards and policies.

2) Understand that service standards and policies are set by board policy and considered management priorities.

3) Be aware that policies and standards used in service development are a balance between cost efficiency and the provision of adequate service to the public.

4) Know that three areas of schedule development most greatly influenced by service standards and policies are 1) route structure, 2) service frequencies and 3) service timing.

5) Learn that route structure defines where the route will go and is related to the interconnectedness of the entire service network.

6) Know also that three areas of route structure include cycle times, route configurations and interlining.

7) Be able to recognize the definitions of route cycle, route configuration and interlining.

8) Understand that maximizing the route length to cycle time utilizes equipment and labor time more efficiently.

9) Recognize how the maintenance of a fixed headway (frequency) can lead to additional layover/recovery time.

10) Understand how planning for vehicles to arrive at a common location for a timed transfer affects cycle times.

11) Be able to recognize diagrams for branches, loops and short turns.

12) Be knowledgeable of the three types of service frequencies – policy (minimum), demand-based and performance-based frequencies.

13) Remember the four typical service timing standards and policies are 1) transfer connections, 2) trunk intertiming, 3) clock frequencies and 4) service timing hierarchy.

I. Introduction

Within the transit organization, the development of service schedules is heavily influenced by organizational service standards and policies. These standards and policies establish *guidelines* on how service can be developed and scheduled.

II. Service Standards and Policies

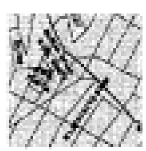
Service standards and polices generally are set by board policy and considered management priorities. As such, they tend to vary from one organization to another.

Policies and standards are generally designed to provide a logical balance between optimal cost efficiency and the provision of adequate service to the public.

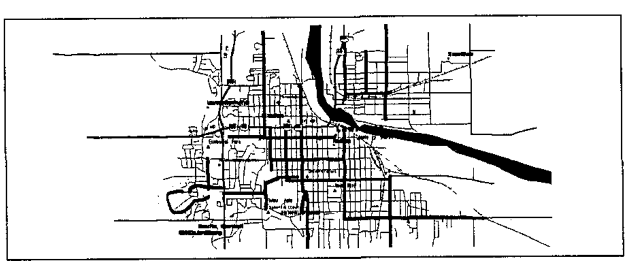
Three areas of schedule development that are most greatly influenced by service standards and policies are:

1)	Route structure	Where the vehicle travels during the service day
2)	Service frequencies	How often a vehicle comes by on the route
3)	Service timing	When the vehicle comes by on the route

Route structure



Where the vehicle travels on a route during the service day is, to a great degree, related to the interconnectedness of the service network.



The structure of individual routes and how they interconnect with other routes are part of route structure.

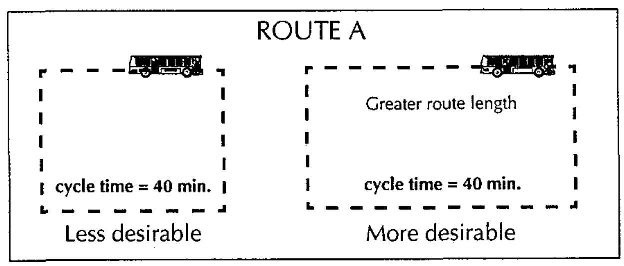
Three areas of route structure that are most influenced by service standards and policies are

a) route cycle times,
b) route configurations, and
c) interlining.

Route cycle times

Cycle time is the time it takes to drive a round trip on a route plus any time that the operator and vehicle are scheduled to take a break (layover and/or recovery time) before starting out on another trip.

Typical service standards attempt to MAXIMIZE THE LENGTH OF THE ROUTE DESIGN per cycle time, while providing for the minimum amount of layover/recovery time allowed.



Maximizing the route length per cycle time facilitates the most effective use of equipment and labor.

Maximizing route length per cycle time utilizes equipment and labor power most effectively. However, other considerations make this optimization difficult to achieve.

Other considerations that make optimization of labor and equipment difficult include...

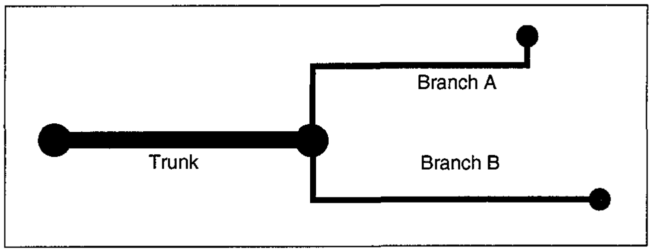
- the need to maintain consistent time between vehicles on a route (headway),
- adjusting for changes in ridership and traffic during the day (for example, rush hour vs. non rush hour), and
- planning for vehicles to arrive at common locations so that passengers may make transfers to other routes (timed transfers).

These considerations often require additional layover/recovery time beyond the mininum allowed.

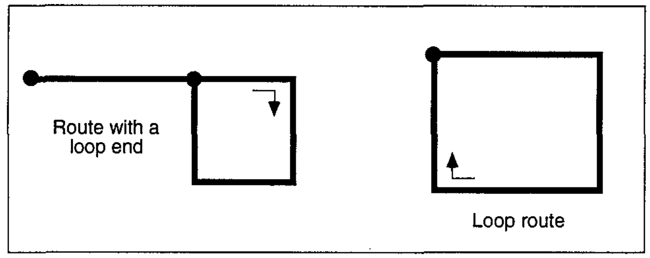
Route configurations

Route configuration is basically the definition of where the route goes. If a route is configured in a complex way, it is difficult to schedule the vehicles to be evenly spaced throughout the route (maintaining a consistent headway). However, a complex route can often lead to reduced costs because equipment and labor can be better optimized. Again, service policies and standards generally dictate a type of balance between cost efficiency and service to the public.

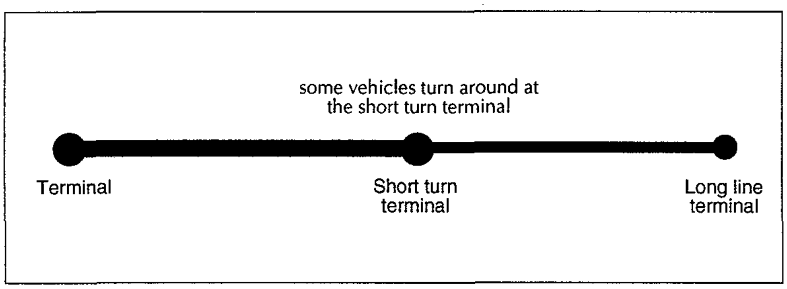
Some examples of typical route configurations



Branches



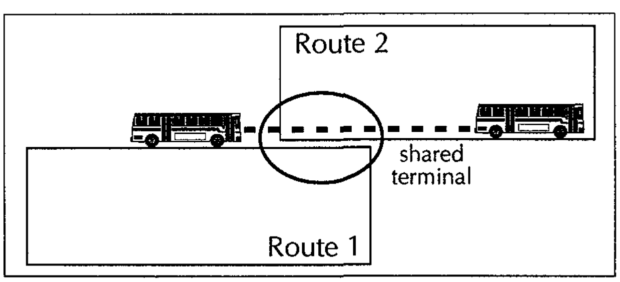
Loops



Short turn

Interlining

Interlining is the term used for scheduling a vehicle to operate from one route to another during a service day. When a vehicle is scheduled to switch over from Route 1 to Route 2, the routes are said to be interlined.



Interlining is the process of scheduling a vehicle to travel from one route to another during a service day.

Optimal interlining can result in reduced costs to the agency AND provide a convenience to the passenger. Interlining is often done for one of the following four reasons:

1- Eliminate end-of-line looping. Often a vehicle is scheduled to loop around at the end of the line. This same loop may also be done by another vehicle on another route. Combining the two loops by interlining reduces redundant time and mileage costs.

2- Lack of layover locations. Locating suitable locations for a vehicle to "park" during layover is often difficult or impossible in certain areas. Interlining can allow the vehicle to layover at a location on another route.

3 - Optimization of cycle times. The interlining of two routes with non-optimal cycle times at a common location can create overall compatible cycle times for the route pair.

4 - Reducing passenger transfers. For passengers traveling to a location that requires them to transfer from one bus to another, an interline of those routes eliminates the need to make the transfer.

Review key points by answering these questions.

1) The development of service schedules is heavily influenced by organizational service standards and policies. True or False

2) Policies and standards are generally designed to provide a logical balance between optimal cost efficiency and the provision of adequate service to the public. True or False

3) Which of the following are greatly influenced by service standards and policies?
   a) route structure c) service timing
   b) service frequencies d) management priorities

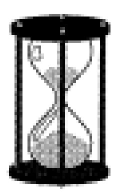
4) Where the vehicle travels on a route during the service day is related to the interconnectedness of the entire service network. True or False

5) Typical service standards attempt to maximize / minimize (choose one) the length of the route design per cycle time.

6) Three areas of route structure that are most influenced by service standards and policies are...
   a) route cycle times c) interlining
   b) route configurations d) ride checks

7) Describe any one of the four examples given for interlining.

III. Service Frequencies



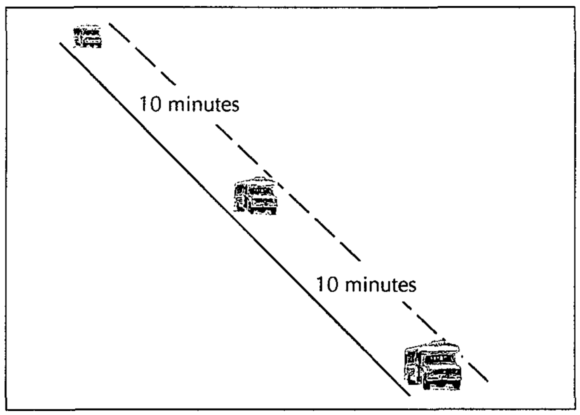
Service policies and standards also affect the development of service frequencies, i.e., <u>how often</u> a vehicle will come by on the route - also commonly referred to as "headway."

Three principal service policies or standards generally govern how often a vehicle is scheduled to come by on a route. They are

a) policy (or minimum) frequency,
b) demand-based frequencies, and
c) performance-based frequencies.

Policy frequencies

Some agencies simply establish by policy or standard, that on a given route, a vehicle will come by at fixed intervals — for example, every <u>x</u> minutes.



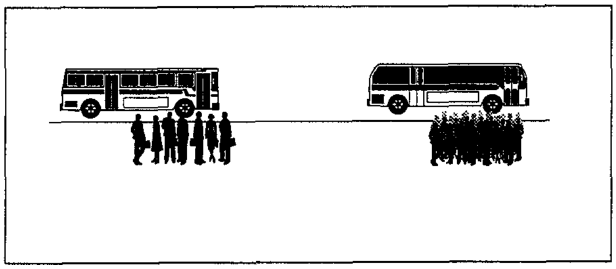
Policy frequencies often establish that a vehicle will come by on the route at fixed intervals.

A vehicle coming by every 60 minutes would be a low frequency service, while a vehicle coming by every 10 minutes would be considered a high frequency service.

Fixed interval service is a convenience to the passengers, because they know a vehicle will come by at regular intervals. However, scheduling for policy (minimum) frequencies can create cost inefficiencies by requiring excessive layover/recovery time to keep the time between vehicles constant.

Demand-based frequencies

With demand-based frequencies (or headways), the agency policy dictates that the level of service provided on the route is directly related to the number of passengers riding at one time (passenger load) and the vehicle capacity required to carry them.



Demand-based frequencies result in a level of service that is based on passenger load.

Determining passenger loading requirements is often done primarily through two methods:

Ride checks One or more data collectors rides a vehicle along the route and notes the number and locations of passenger boardings and deboardings.

Point checks One or more data collectors located at strategic points along the route records passenger boarding, deboarding and time information.

Meeting passenger load requirements of demand-based frequencies often requires adjustments in service frequency, multiple trips and/or adjusting vehicle size and capacity.

Performance-based frequencies

With this approach, service frequencies are **goal-oriented** and based on targeted performance standards. These performance standards are measured during a given service period or service day.

Performance measures typically include one or more of the following formulas.
(Note that "revenue" hours or miles means that the vehicle is in service and collecting passengers. It also includes layover time.)

Performance Measures

SERVICE EFFECTIVENESS (productivity)

- **Passengers** per **Revenue Hour**
- **Passengers** per **Revenue Mile**
- **Passengers** per **Vehicle Trip**

COST EFFECTIVENESS

- **Operating Expense** per **Passenger**
- **Operating Expense** per **Passenger Mile**

OVERALL EFFECTIVENESS

- **Net Subsidy** per **Passenger**
- **Net Subsidy** per **Passenger Mile**
- **Farebox Revenue** per **Cost of Service (Operating Ratio)**

IV. Service Timing

Service policies and standards influence when vehicles will come by on the system (service timing).

Four typical service timing policies are

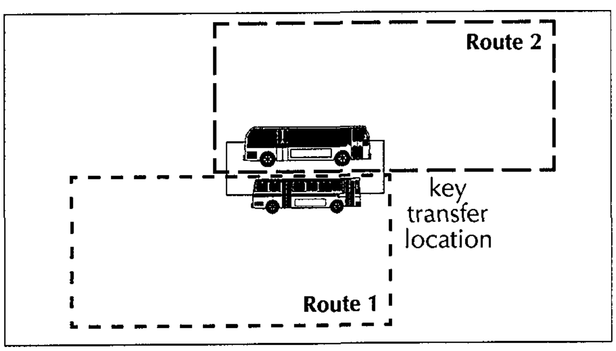
a) transfer connections,
b) trunk intertiming,
c) clock frequencies,
d) service timing hierarchy.

Transfer connections

Transit systems, depending on their size, generally need to identify key transfer connections (locations and times) that must occur in order for the entire service network to be successful.

Where service is frequent (15 minute frequencies or less), ad hoc or untimed transfers generally meet passenger needs.

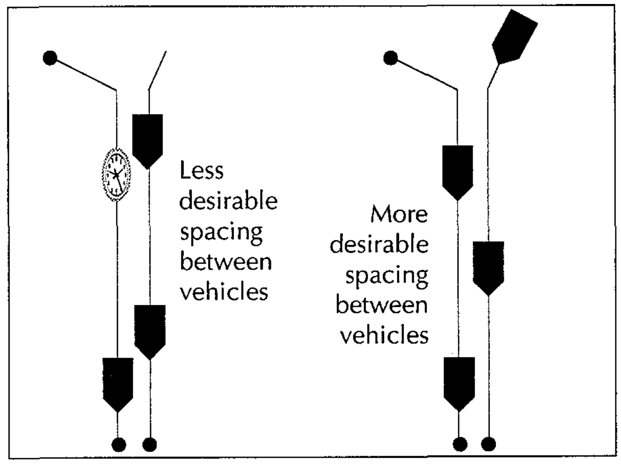
Where service is infrequent, (20 or more minutes between vehicles, timed transfers are desired when possible.



Timed and untimed transfers occur at key transfer locations.

Trunk intertiming

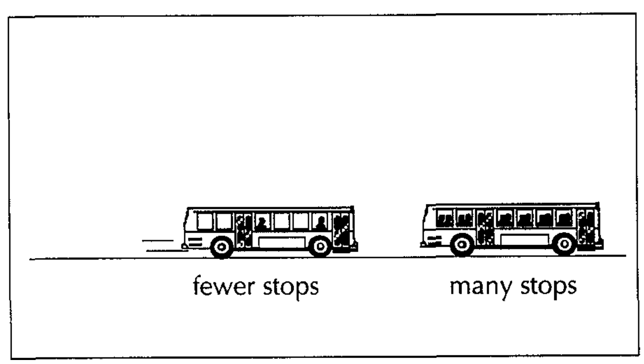
In many cases, trips on one or more routes serve a "common corridor." Coordinating the timing of these trips can result in better service to the passengers in at least two ways.



Intertiming trips that serve a common corridor results in more even frequencies and more balanced passenger loads.

First, by timing the vehicles from different routes (or multiple vehicles making trips on the same route) to be evenly spaced along the corridor, the service frequency (headway) can maintain its evenness. The passenger knows another vehicle will be along in __x__ minutes.

Secondly, the even spacing of vehicles helps to prevent "bunching." Bunching can occur when vehicles with lighter passenger loads catch up to vehicles with heavier loads. The heavier load vehicles run slower because they make more frequent stops.



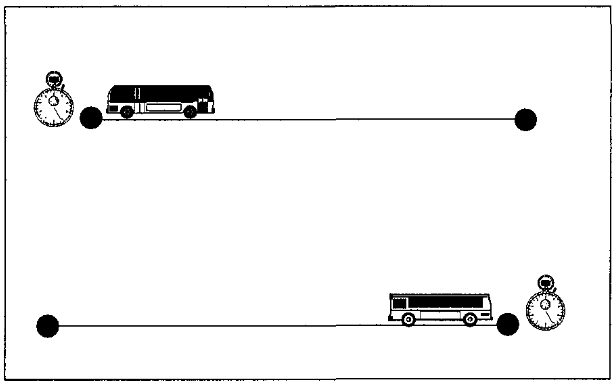
Bunching occurs when vehicles with lighter loads catch up to vehicles with heavier loads.

Clock frequencies

Clock frequencies describe trips that are scheduled to be at selected locations at regular intervals past the hour.

Scheduling vehicles to come by passenger stops at regular clock intervals is intended to be a convenience to passengers.

For example, a passenger would know that the next vehicles are scheduled to come by at 16, 26, 36, 46 minutes past the hour and so on.



With clock frequencies, one time point in each direction keys clock intervals.

Clock frequencies are usually assigned to one time point in each direction, often at the end-of-the-line.

However, it is usually difficult to operate a comprehensive clock-based system and still make necessary adjustments in running times throughout the service day.

Service timing hierarchy

The timing hierarchy identifies key time points which drive the development of individual schedules.

In the case of *timed* transfers, the hierarchy determines on which routes in the system the transfer connections are based.

As a result, there are usually two service timing hierarchies–one at the system level and one for each individual route.

Review key points by answering these questions.

1) Which one is goal-oriented: demand-based frequencies or performance-based frequencies?

2) Determining passenger loading requirements is often done primarily through which of the following methods? (choose two)
   a) ride checks c) point checks
   b) call checks d) drive checks

3) "Revenue hours" means that the vehicle is in service and collecting passengers.
   True or False

4) Transfer connections, trunk intertiming, clock frequencies and service timing hierarchy are all part of...
   a) route configuration c) service frequency
   b) service timing d) none of the above

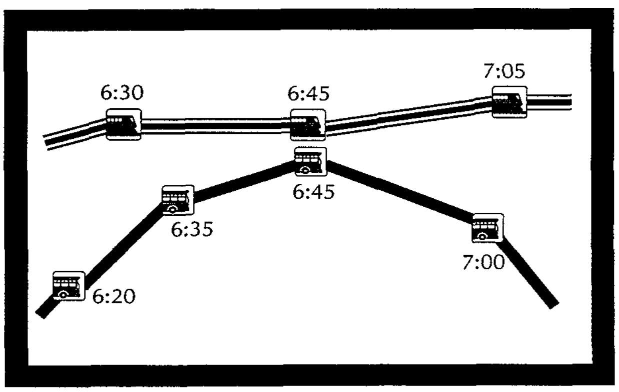
5) Where service is frequent, ad hoc or untimed transfers generally meet passenger needs.
   True or False

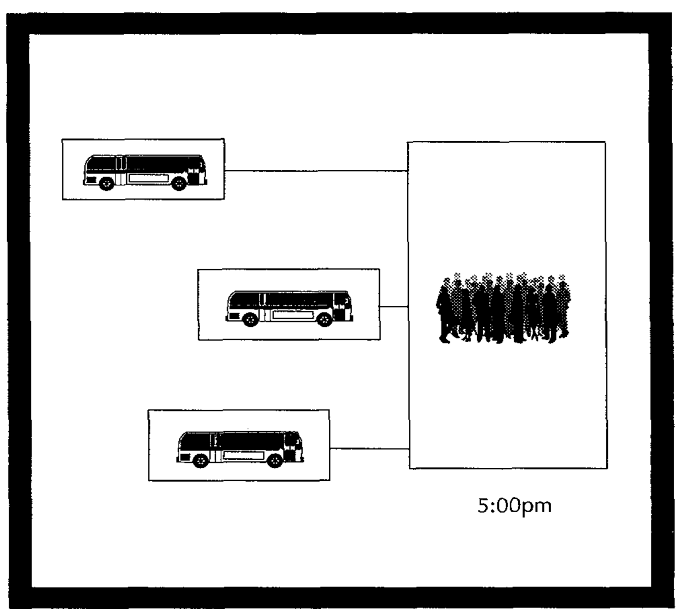
6) Describe what occurs with "bunching."

Notes:

CHAPTER 2

TRIP
GENERATION





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Study Objectives

1) Learn that trip generation (trip building) is the process of developing the service schedule for a route.

2) Remember what the public version of a service schedule is called.

3) Be able to recognize the definition of span of service.

4) Know the significance of the maximum load point.

5) Understand the difference between demand-based and policy-based scheduling.

6) Remember the definition of headway.

7) Learn the diagrams of branches, loops and short turns.

8) Be able to relate the number of terminal points to typical types of routes.

9) Learn the definition of cycle time.

10) Remember the difference between minimum and available cycle time.

11) Given the headway and cycle time for a route, be able to compute the number of vehicles needed to provide service on that route.

12) Learn the definition of an intermediate time point, how it is often referred to in computerized scheduling, and what location characteristics make good intermediate time points.

13) Be able to describe the difference between an internal time point and a time point found on a public timetable.

14) Learn the definition of running time.

15) Understand what operators do at relief points.

16) Remember that timed transfer considerations require revenue vehicles to converge at a common transfer location.

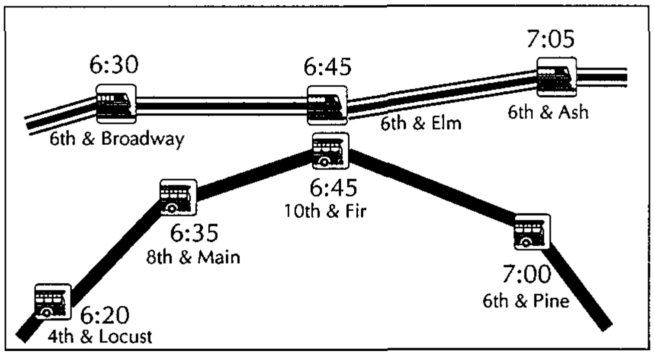
17) Given relevant information, be able to build a master schedule for a particular route.

I. Introduction

Trip generation

Trip generation (also called trip building) is the process of developing the "master" service schedule for a route.

The master service schedule, or simply, the master schedule, indicates all the times that revenue service vehicles are scheduled to be at specific locations along the route.



Trip generation is the process of determining when and where vehicles will be on a route.

The customer version of the service schedule is often called a public timetable.

Trip generation requires input from the Scheduling department as well as information from other departments, such as Planning, Operations, Marketing and Finance.

II. Policy and Planning Criteria

Span of service

The "span of service" is the duration of time (measured in hours and minutes) that vehicles are available for passenger service on a route.

The service span is measured from the beginning time of the first trip on the route to the end time of the last trip on that route.

Maximum load point

The maximum load point(s) (MLPs) is (are) the location(s) along a route where the greatest number of passengers are on board.

Having this maximum load point information, along with other factors, allows the scheduler to determine the number of vehicles that will need to pass the MLP in order to accommodate the passengers wanting to use the service.

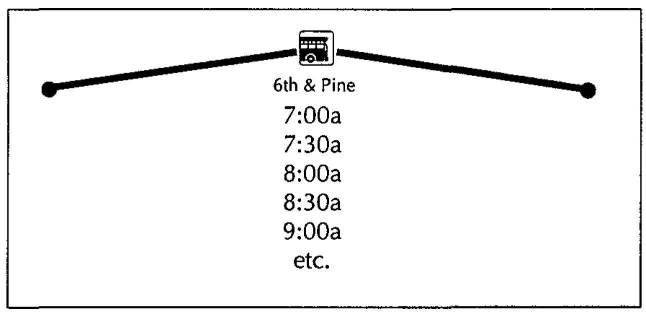
Headway

The "headway" is the time interval between two consecutive revenue vehicles operating in the same direction on a route. This is also referred to as "service frequency."

As mentioned in Chapter 1, the headway or service frequency on a route is determined either by company policy or by demand as determined by factors such as the MLP.

Policy-based frequencies

Where schedules maintain a consistent and fixed interval between vehicles on the route, the schedule is said to be "policy based."



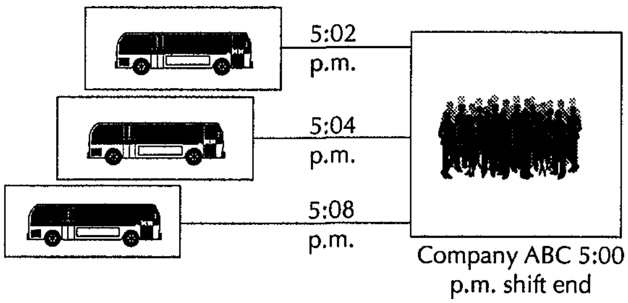
Policy-based headways operate at fixed intervals.

The fixed headway between vehicles is likely the result of low passenger demand and the desire of the company to have a minimum level of service on the route.

The headway on a policy-based schedule will often be an even "clock multiple," most commonly every 10, 15, 20, 30 minutes or on the hour, although not always.

Policy-based schedules are a convenience to the passengers, informing them that a vehicle will arrive at their passenger stop every X minutes past the hour.

Demand-based frequencies



Demand-based schedules include multiple trips spaced to accommodate the number of passengers at the maximum load points.

On routes where the volume of passengers is great at certain times and locations, more trips will need to be scheduled in order to meet the demand.

The appropriate headway for demand-based headways is generally based on

1) the number of passengers wanting the service at various locations (this includes both passengers already on board and those waiting at passenger stops).

2) the number of spaces available on the vehicle (including seats and standing room).

3) the company policy on how many people can be on board (seated and standing) at certain times and on certain vehicles, otherwise known as the "loading standard."

The loading standard is generally expressed as the percentage of passengers allowed on the vehicle to the actual seating capacity of the vehicle.

For example, if the loading standard is established by company policy as 133% on a vehicle with 45 seats, then 60 persons is the target (but not a cutoff) for maximum capacity.

Example:

133% = **60** spaces / **45** seats

loading standard

The loading standard is the percentage of passengers the company will target as a maximum load. It is expressed as a percentage of the number of seats available.

Example: Demand-based frequencies

In this example, 3 trips serve the passenger stop in front of ABC Corporation around 5:00 p.m. as follows:

Current Service

Trip	On Board	Boarding	Total
5:02	34	48	82
5:04	46	35	81
5:08	41	24	65
TOTAL	121	107	228

Loading standard (%) = 125%
Vehicle seating capacity = 45

target maximum # of passengers for each vehicle...

125% * 45 = 57

Since 3 vehicles with a loading standard of 57 each equals 171 (3×57), then 57 passengers (228 - 171) are not being provided rides or are boarding and overcrowding the vehicles.

Solution

Adding another trip by a similar sized vehicle during the period will provide enough vehicle space.

228 / 57 = 4 vehicles

228: riders (spaces needed)
57: spaces per loading standard

Trips to that location around 5:00 p.m. are revised to the following schedule:

Trips

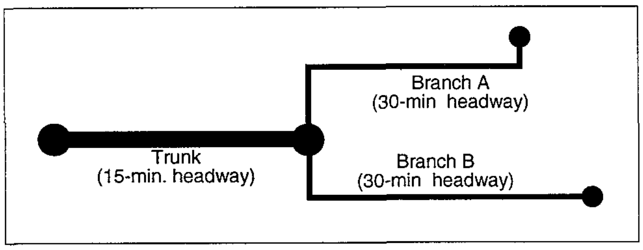
5:00
5:03
5:07
5:12

Route patterns

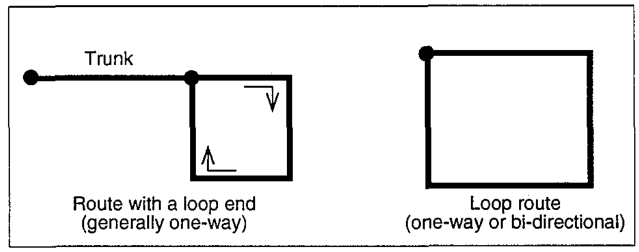
Routes often consist of a trunk or main path providing the same frequency of service over the entire length of the route. Route variations include trips whose path deviates from the trunk in some manner. These basic route deviations are referred to as branches, loops, and short turns.

Examples of branches, loops and short turns

The following diagrams illustrate three typical deviations from the main trunk of a route.

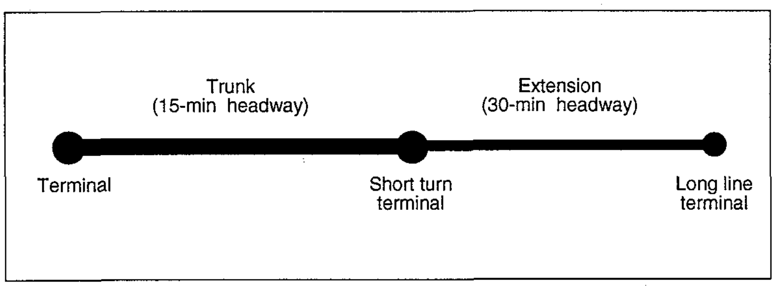


Branches



Loops

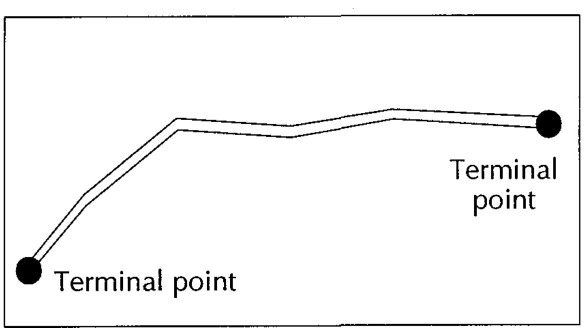
● denotes Terminal Location



Short turn

Terminal points

Terminal points are considered the "ends" of a line or route. These are the locations where vehicles generally begin and/or end their trips and operators usually take their layovers.



Terminal points are considered ends of the line.

For that reason, locations where there is safe parking and restrooms close by are considered desirable locations for terminal points.

How many terminal points are usually on a route?

Loop routes that operate only in one direction generally have only one terminal point.

A basic end-to-end route with bi-directional service and no branches or short turns generally has two terminal points, one located at each end of the route.

Routes with more complex patterns generally have more than two terminal points.

Review key points by answering these questions.

1) The master service schedule indicates all the times that revenue service vehicles are scheduled to be at specific locations along the route.

   True or False

2) The customer version of the service schedule is often called a_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ .

3) What is the span of service?

4) The maximum load point (MLP) represents a point along the route where the *greatest / fewest* (choose one) number of passengers are on board.

5) The headway is the time interval between two consecutive revenue vehicles operating in the same direction on a route. True or False

6) Headway is sometimes referred to as _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _.

7) A fixed headway between vehicles is likely the result of low passenger demand and the desire of the company to have a minimum level of service on the route.

   The above sentence refers to *policy-based* or *demand-based* headways. (choose one)

8) On routes where the volume of passengers is great at certain times and locations, more trips will need to be scheduled in order to meet the demand.

   The above sentence refers to *policy-based* or *demand-based* headways. (choose one)

9) Define loading standard.

10) If a vehicle had 40 seats and a loading standard of 150%, what is the target maximum load?

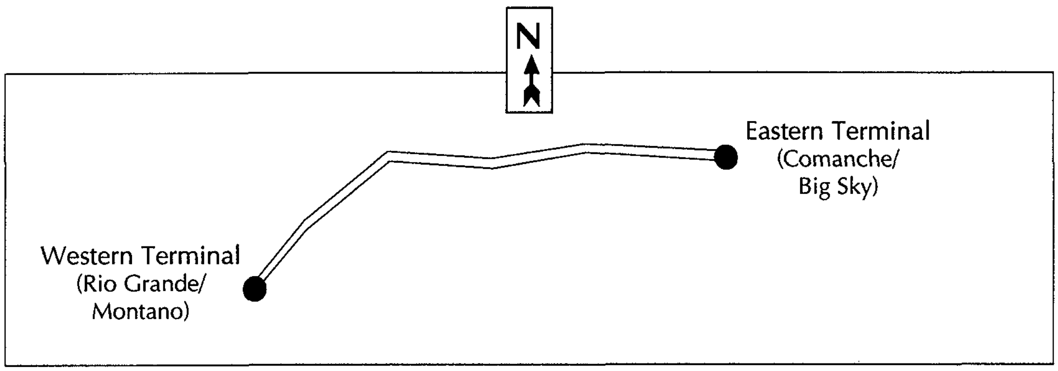
11) Branches, loops and short turns are examples of route pattern variations. True or False

12) Operators generally take their layovers at terminal points. True or False

13) Match the following:

end-to-end route	one terminal
complex route	two terminals
loop route	more than two terminals

IN THE FOLLOWING SECTIONS, ROUTE 32 WILL BE DEVELOPED TO ILLUSTRATE THE TRIP BUILDING PROCESS AND TO DEMONSTRATE NEW CONCEPTS.



Route 32

Route 32 will have two terminals or end points. The western terminal is located at Rio Grande & Montano. The eastern terminal is located at Comanche & Big Sky.

The time it takes for one vehicle to operate passenger service from one terminal to the other (excluding layover/recovery time) is 36 minutes (72 minutes round trip).

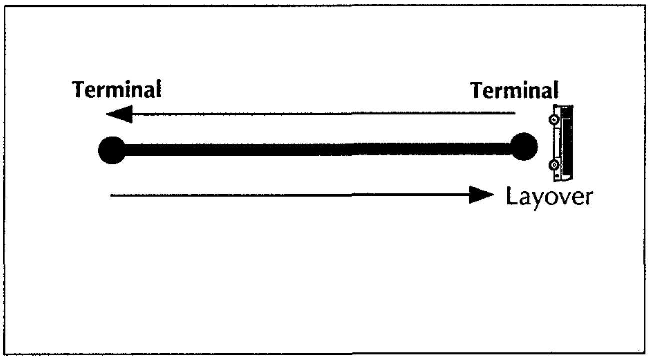
By agency agreement, the minimum layover/recovery time per round trip is established at 10% of the round trip running time.

Trips generated for this route will operate bi-directionally between the two terminals, operating on a policy-based 30-minute headway.

The service span will be during peak hours only. In this case, approximately 6:00 a.m. - 10:30 a.m. and 1:30 p.m. - 6:30 p.m.

Cycle time

Cycle time is the number of minutes needed to make a round trip on the route, including layover/recovery time.



Cycle time is the time needed to make a round trip, including layover/recovery time.

Cycle time is important for several reasons, including playing a part in the formula used for determining the number of vehicles needed to provide a given level of service on a route. (See next page.)

Since cycle time equals the number of minutes needed to make a round trip, including the layover/recovery time, the scheduler determines the amount of time it takes to operate or "run" from one end of the route to the other and back, then adds layover/recovery time to yield the cycle time.

Minimum vs. Available Cycle Time

For many agencies, on some or all routes, the amount of layover/recovery time is often determined by labor agreement or agency policy.

These agreements or policies dictate a minimum number of minutes that must be built into the schedule for layover/recovery.

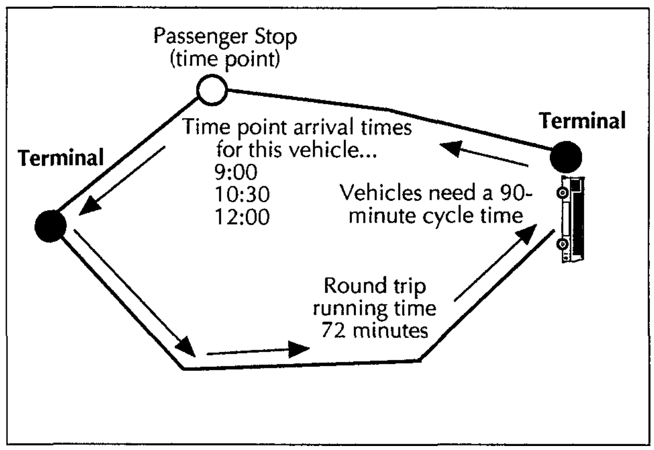
Minimum cycle time is the number of minutes scheduled for the vehicle to make a round trip, including a minimum layover/recovery time as dictated by labor agreement or agency policy. In the example of Route 32, the minimum layover/recovery time is 10% of the round trip time.

However, maintaining a constant headway, such as the policy-based, 30-minute headway for Route 32, will, in most cases, result in a cycle time OTHER THAN THE MINIMUM CYCLE TIME for the vehicles operating that route.

In the case of Route 32, it will be necessary for vehicles to layover/recover longer than the minimum 10% agency requirement. Otherwise, they would leave the layover point too soon and arrive at the stops along the route sooner than the schedule indicates.

Therefore, additional (sometimes called "excessive") layover/recovery time is necessary to maintain the 30-minute headway on Route 32.

The resulting cycle time (which includes the additional layover/recovery time) necessary to maintain the 30-minute headways is now called the *available cycle time.*



Available cycle time includes excessive layover/recovery time necessary to maintain constant headways.

In the optimal case, the minimum cycle time would be the same as the available cycle time. However, maintaining fixed, clock multiple headways often makes that impossible.

So how many vehicles would be needed to maintain the 30-minute headway on Route 32?

To operate the 30-minute headway on Route 32 (or any consistent headway on any route), a simple formula is used to determine the number of vehicles needed.

$$\frac{\text{Cycle time}}{\text{Desired Headway}} = \textbf{\# Vehicles}$$

Formula for computing the number of vehicles needed to operate a given headway.

Given the minimum layover/recovery time for Route 32 of 10% of round trip time, the number of vehicles needed is initially computed as follows:

Minimum cycle time:

= (round trip time + min. layover/recovery)
= (72 + (10% × 72))
= (72 + 7.2)
(7.2 is rounded to the next whole number 8)
= **(72 + 8)**
= 80

Desired Headway:
= (30) minutes

$$\frac{80}{30} = \mathbf{2.67}$$

Obviously, it is not possible to operate 2.67 vehicles. The number of vehicles needed would be rounded up to three (3).

Substituting 3 for 2.67 means the cycle time would have to change if the 30-minute headway remains constant.

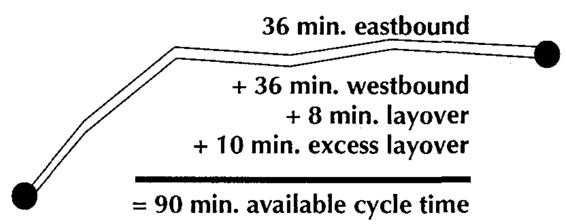
$$\frac{\textbf{?}\ \text{(cycle time)}}{30\ \text{(minute headway)}} = \textbf{3 vehicles}$$

Solving the equation for available cycle time...

$$\frac{\mathbf{90}}{30} = 3$$

Maintaining the 30-minute headway yields an <u>available</u> cycle time of 90 minutes.

With a round trip running time of 72 minutes, this means that **18 minutes** of layover/recovery time per round trip is necessary to maintain the 30-minute headway, while utilizing 3 vehicles.



Ninety minutes of available cycle time for Route 32 includes 18 minutes of layover/recovery per round trip.

In general, can schedulers do anything else with excess layover/recovery time?

Excess layover/recovery time generally is used by the scheduler in one of 5 different ways:

1) to maintain consistent headways (as with Route 32).

2) to allow route deviations (changes in where the vehicle goes on the route).

3) to modify the headway (i.e., longer or shorter headways for more efficient vehicle utilization).

4) to lengthen the route where there is enough available cycle time.

5) to facilitate interlining with other routes.

Recap of cycle time, # of vehicles, headway, and span of service for Route 32

Westbound running time	=	36 minutes	Westbound running time	=	36 minutes
Eastbound running time	=	36 minutes	Eastbound running time	=	36 minutes
TOTAL RUNNING TIME	=	72 MINUTES	TOTAL RUNNING TIME	=	72 MINUTES
Contract layover (10%)	=	8 minutes	Layover for 30-min. headway	=	18 minutes
MINIMUM CYCLE TIME	**=**	**80 MINUTES**	**AVAILABLE CYCLE TIME**	**=**	**90 MINUTES**

$$\text{\# Vehicles} = \frac{90}{30} = \underline{\ 3\ }$$

Headway = 30 minutes

Span of service:

Peak service hours 6:00 a.m. - 10:30 a.m.

and 1:30 p.m. - 6:30 p.m. weekdays

III. Other Data

Intermediate time points

Intermediate time points are locations along the route, between the terminals, that indicate when the vehicle will be there. The term "node" is commonly used in computerized scheduling systems to denote a time point.

Generally speaking, on public timetables, these intermediate time points, or nodes, are timed to be between 6 and 10 minutes apart.

In theory, when intermediate time points are too close together, there is a greater risk that the operator may arrive early and have to wait or "dwell" at that point to stay on schedule, causing passengers to become impatient.

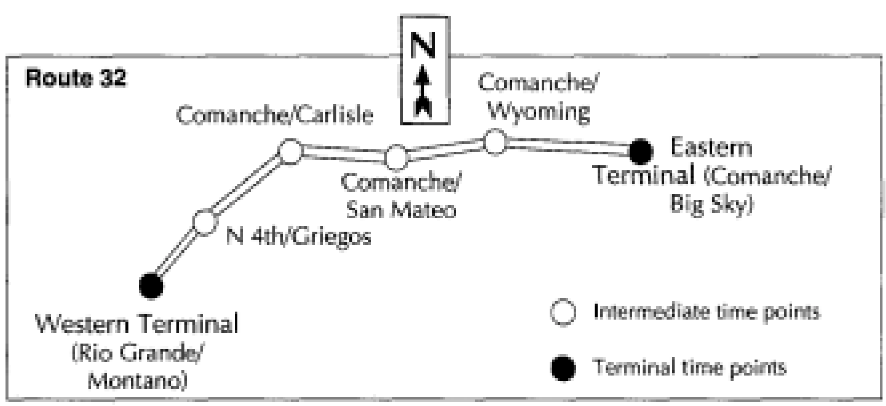
When time points are more than 10 minutes apart, some agencies believe that customers are more likely to be confused about when a vehicle will arrive at a particular stop, given the differences in individual operator driving habits.

Where are intermediate time points typically located?

Physical location considerations also affect the selection of intermediate time points. <u>Major intersections</u> that are widely recognized and possess good pedestrian amenities like sidewalks and actuated traffic signals make good time points.

It is a good idea to locate intermediate time points at major trip generator locations such as shopping centers, hospitals, and government buildings. Time points are also useful at locations where time is critical, such as major employment centers and intersecting bus routes or rail centers.

Route 32 has four (4) intermediate time points.



Internal time points

Internal time points provide more detailed location and time information. They may appear on the schedule used by the operator (sometimes called a run paddle) but not on the public timetables.

These internal time points, typically spaced three (3) to five (5) minutes apart, are meant to serve as a reference for both operators and supervisors to determine if a particular trip is running early (hot) or late.

Running time

Running time refers to the number of scheduled minutes assigned to a revenue vehicle for moving from one time point location to the next.

Running times are accurate when they are sensitive to the varying traffic conditions and passenger volumes over the course of a service day.

Too little running time can cause operators to become frustrated and rushed trying to stay on time, creating potential safety problems such as speeding, pushing traffic lights and being abrupt with passengers.

Too much running time creates unnecessary travel time for passengers and the inefficient utilization of equipment and operators. It may also contribute to operators running early (hot), which may result in some passengers missing their trips.

Inaccurate running times also contribute to missed transfers, schedule reliability complaints and time-consuming (and expensive) schedule corrections.

Running time files

Because running times between time points often vary by time of day or day of the week, they are often stored in a running time file. In a typical example of a running time file, the names of time points are listed down the left-hand column while timing periods are listed across the top.

ROUTE 32 (Example running time file)

Service Day: Weekday

Direction: Westbound

Time Point	Early A.M.	A.M. Peak	Base	School	P.M. Peak	Evening	Night
Comanche @ Big Sky	-	-	-	-	-	-	-
Comanche @ Wyoming	9	9	-	-	9	9	-
Comanche @ San Mateo	6	6	-	-	6	6	-
Comanche @ Carlisle	4	4	-	-	4	4	-
N. 4th @ Griegos	10	10	-	-	10	10	-
Rio Grande @ Montano	7	7	-	-	7	7	-
TOTAL	36	36	-	-	36	36	-

Example running time file for Route 32

Review key points by answering these questions.

1) Cycle time is the number of minutes needed to make a round trip on a route, including layover/ recovery time. True or False

2) Minimum cycle time includes a minimum layover/recovery time generally determined by labor agreement or agency policy. True or False

3) Maintaining consistent headways may result in a cycle time other than the minimum cycle time. rue or False

4) Cycle time that includes excessive layover/recovery time is called _ _ _ _ _ _ _ _ _ cycle time.

5) Write the formula used for computing the number of vehicles needed to operate a route.

6) Which of the following was not listed as a consideration for the scheduler when dealing with excessive cycle time?
   a) to maintain consistent headways
   b) to shorten the route
   c) to allow route deviations
   d) to facilitate interlining with other routes

7) A "node" is a time point. True or False

8) Major intersections that are widely recognized and possess good pedestrian amenities like sidewalks and actuated traffic signals make good time points. True or False

9) Internal time points are often found on public timetables. True or False

10) Running time refers to the number of scheduled minutes assigned to a revenue vehicle to move from one time point location to _______________.

11) Match the following:

	Too much running time	abruptness with passengers
	Too little running time	unnecessary passenger travel time

12) What does a running time file do?

Controlling time points

Most schedules are constructed around one or more controlling time points. Controlling time points are specific arrival and/or departure locations that affect one or more trips along the route.

Specific arrival and/or departure times may result from the need to be at a certain location at a certain time, generally because a major passenger load can be expected. Examples include schools, major employment centers and coordinated (timed) transfers between two revenue service vehicles.

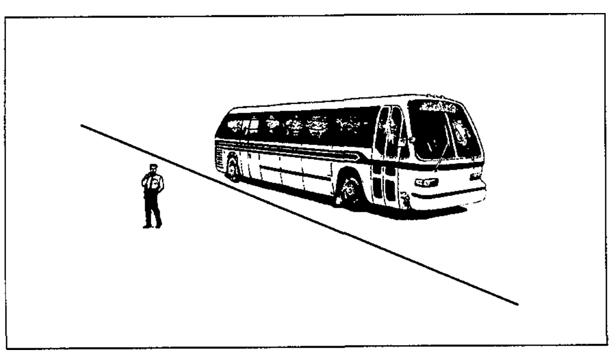
Controlling time points often include the maximum load point on a route.

Relief points

Relief points are points along the route where an operator (but not necessarily a vehicle) begins (and another operator ends) a work shift or part of a work shift.

Although operators may typically begin their service day at the garage facility and drive the revenue vehicle to a starting point along the route (usually a terminal), many operators relieve other operators at a point along the route at a given time and proceed along the route with that vehicle.

This typically occurs when the total number of hours that a revenue service vehicle operates in a given workday exceeds the time that a single operator can work.

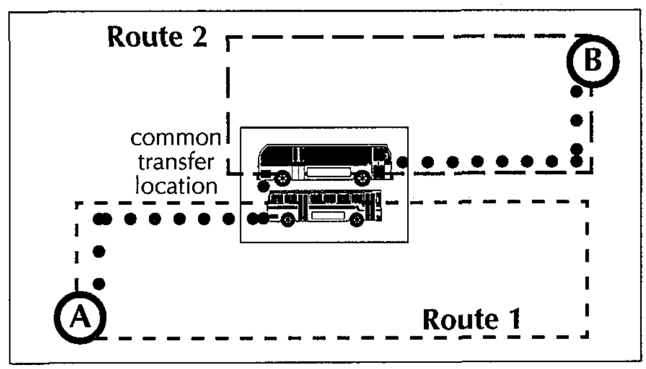


Relief points are locations where one operator relieves another operator and continues in revenue service with that vehicle.

Timed transfer considerations

Coordinating passenger transfers between revenue vehicles operating on different routes may require those vehicles to converge at a common transfer location at the same time.

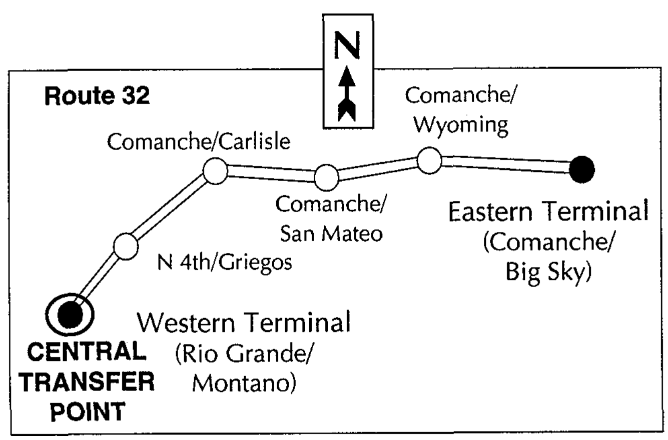
Passengers can then leave the first vehicle and transfer to the next vehicle for a continuing trip on another route (as in point A to B below).



Timed transfers require that vehicles converge upon a common location so that passengers can depart one vehicle to board another.

For Route 32, the western terminal is considered the central transfer point for the system.

Therefore, arrival times need to be timed in order to accommodate passenger transfers from Route 32 to other routes.



For Route 32, the western terminal is the central transfer point where passengers can transfer to other routes.

IV. Master Schedule Development

The next step in the process is to build individual trips into a master schedule for the route. The master schedule depicts all trips made on that route. Different master schedules typically cover weekdays, Saturdays and/or Sundays and/or holidays for a given route.

Format

Master schedules are built utilizing a format that lists the trips either vertically or horizontally. Vertical listing of trips will be used for Route 32.

Abbreviations

Time points are often abbreviated into standard three or four digit codes. Most computerized scheduling systems require abbreviations. Route 32 time points will be abbreviated as follows:

CBS	Comanche @ Big Sky
COW	Comanche @ Wyoming
CSM	Comanche @ San Mateo
COC	Comanche @ Carlisle
4GR	N. 4th @ Griegos
RGM	Rio Grande @ Montano

Building a base headway

As previously noted, Route 32 is intended to operate a 30-minute headway during peak hours only (approximately 6:00 a.m. - 10:30 a.m. and 1:30 p.m. - 6:30 p.m.). No off-peak or evening trips are needed. Three vehicles will be used.

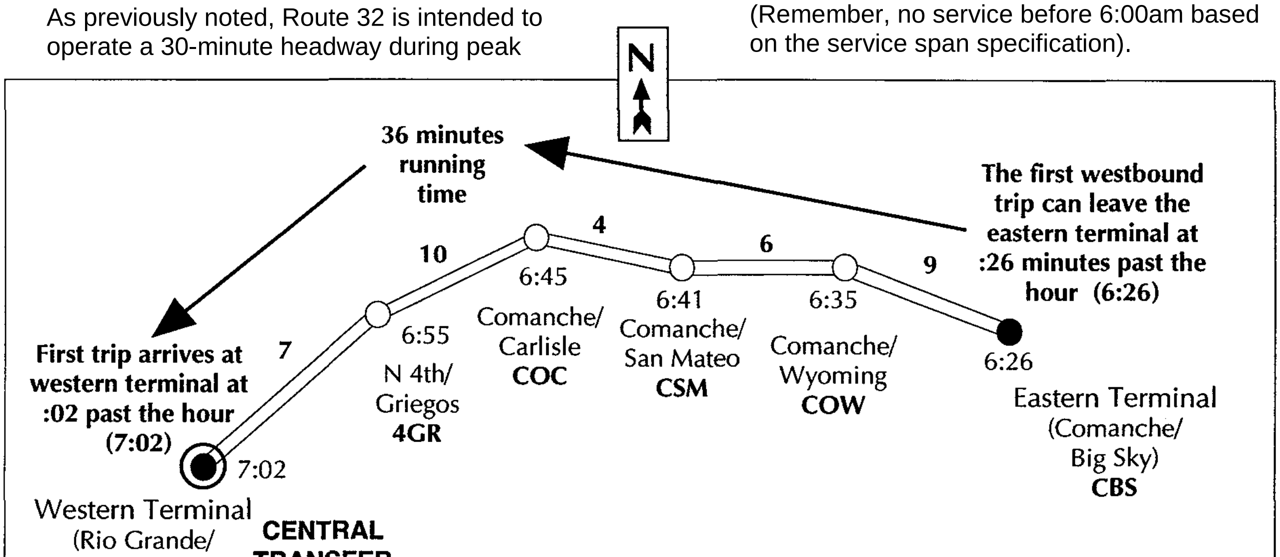
Which trips will be built first, westbound or eastbound?

A number of factors can influence the initiation of trip building by direction. In the case of Route 32, the western terminal is considered the central transfer point for the system. Since Route 32 trips need to converge on the western (outer) terminal at specific times to facilitate timed transfers, westbound trips will be generated first.

How are departure times for the trips determined?

Typically, selected routes converge on a transfer center at about the same time. Since other routes in the system converge on the western terminal (the central transfer location) at :02 and :32 past the hour, trips on Route 32 should also converge there at :02 and :32 past the hour.

Since the running time for westbound trips has been established at 36 minutes, the first trip leaving the eastern terminal must leave at 6:26 a.m. to arrive 36 minutes later at 7:02 a.m. (Remember, no service before 6:00am based on the service span specification).



The first westbound A.M. trip would leave at 6:26 in order to arrive at the western terminal 36 minutes later at 7:02

Since Route 32 is operating a <u>30-minute headway</u>, the next westbound trip (2W) has to depart the eastern terminal (**CBS**) at _______ (fill in the time).

The remaining westbound trips, as seen below, are now generated as the master schedule for Route 32 continues to build with westbound A.M. trips. The times for each time point are derived from the running times file presented earlier, and the intent to maintain a 30-minute headway.

Route 32 - Westbound
Weekday

Trip No.	CBS	COW	CSM	COC	4GR	RGM
1W	6:26	6:35	6:41	6:45	6:55	7:02
2W	6:56	7:05	7:11	7:15	7:25	7:32
3W	7:26	7:35	7:41	7:45	7:55	8:02
4W	7:56	8:05	8:11	8:15	8:25	8:32
5W	8:26	8:35	8:41	8:45	8:55	9:02
6W	8:56	9:05	9:11	9:15	9:25	9:32
7W	9:26	9:35	9:41	9:45	9:55	10:02
8W	9:56	10:05	10:11	10:15	10:25	10:32

The P.M. westbound weekday trips are built next. Again, the P.M. service plan is to operate from approximately 1:30 p.m. until 6:30 p.m. The first P.M. trip, 9W, must leave the eastern terminal at 1:26 to arrive at the western terminal at 2:02. The last trip, 18W, is scheduled to arrive at RGM at 6:32.

Continue building the master schedule by completing the times for the remaining P.M. westbound trips. (Answers are on the next page.)

9W	**1:26**	**1:35**	**1:41**	**1:45**	**1:55**	**2:02**
10W						
11W						
12W						
13W						
14W						
15W						
16W						
17W						
18W						**6:32**

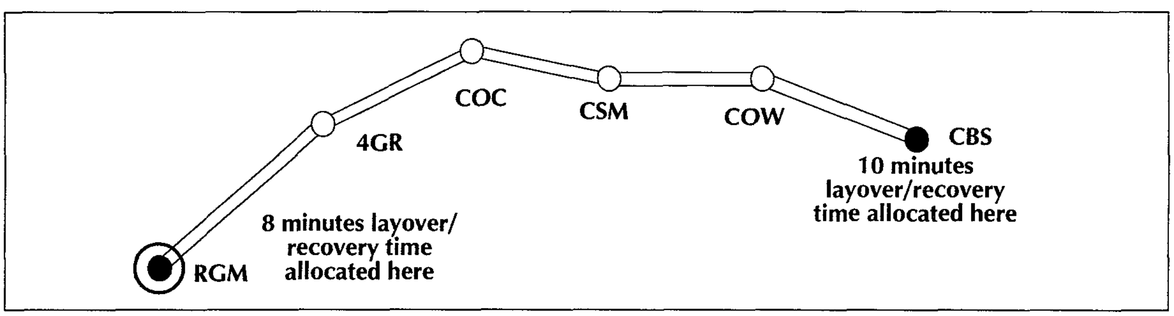
Route 32 - Westbound
Weekday

Trip No.	CBS	COW	CSM	COC	4GR	RGM
1W	6:26	6:35	6:41	6:45	6:55	7:02
2W	6:56	7:05	7:11	7:15	7:25	7:32
3W	7:26	7:35	7:41	7:45	7:55	8:02
4W	7:56	8:05	8:11	8:15	8:25	8:32
5W	8:26	8:35	8:41	8:45	8:55	9:02
6W	8:56	9:05	9:11	9:15	9:25	9:32
7W	9:26	9:35	9:41	9:45	9:55	10:02
8W	9:56	10:05	10:11	10:15	10:25	10:32
9W	**1:26**	**1:35**	**1:41**	**1:45**	**1:55**	**2:02**
10W	**1:56**	**2:05**	**2:11**	**2:15**	**2:25**	**2:32**
11W	**2:26**	**2:35**	**2:41**	**2:45**	**2:55**	**3:02**
12W	**2:56**	**3:05**	**3:11**	**3:15**	**3:25**	**3:32**
13W	**3:26**	**3:35**	**3:41**	**3:45**	**3:55**	**4:02**
14W	**3:56**	**4:05**	**4:11**	**4:15**	**4:25**	**4:32**
15W	**4:26**	**4:35**	**4:41**	**4:45**	**4:55**	**5:02**
16W	**4:56**	**5:05**	**5:11**	**5:15**	**5:25**	**5:32**
17W	**5:26**	**5:35**	**5:41**	**5:45**	**5:55**	**6:02**
18W	**5:56**	**6:05**	**6:11**	**6:15**	**6:25**	**6:32**

Now that westbound trips are scheduled, how are the eastbound trips added?

Building the eastbound weekday trips on Route 32 follows much the same process, except that layover/recovery time has yet to be allocated. In this case, the **18** minutes of layover/recovery must be built into the schedule per round trip.

It has been arbitrarily determined by the agency that 8 minutes will be taken at the western terminal (**RGM**) and 10 minutes will be taken at the eastern terminal (**CBS**).



8 minutes of layover/recovery time is to be taken at the western terminal (RGM) and 10 minutes at the eastern terminal (CBS).

Eastbound weekday trips for Route 32

When does the first eastbound trip start?

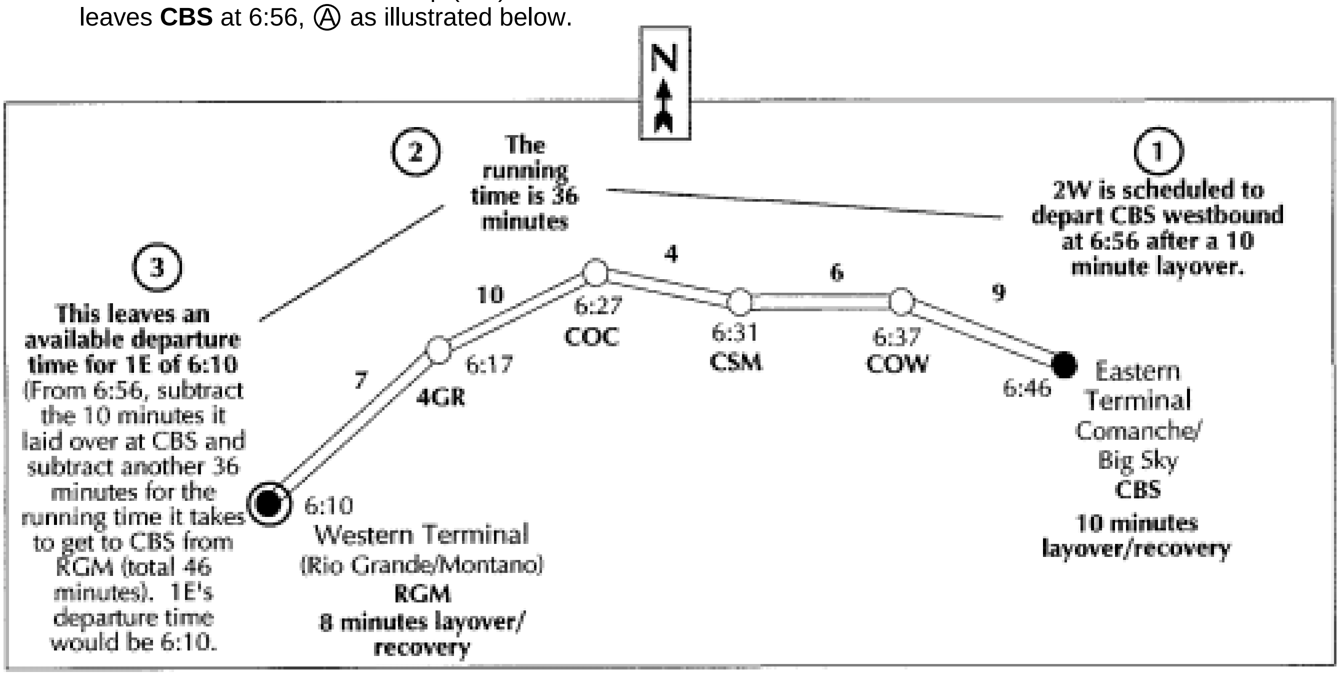
Schedulers often think in terms of "tying" or "hooking" trips together. In this case, they might see if the vehicle already scheduled to make the first westbound trip (1W at 6:26) could make an eastbound trip first.

The first eastbound trip (1E) preceding 1W would have to leave eastbound well before the planned 6:00 a.m. span of service. However, (1E) could start eastbound at 6:10 a.m. and make the second westbound trip (2W), which leaves **CBS** at 6:56, Ⓐ as illustrated below.

Route 32 - Westbound
Weekday

Trip No	CBS	COW	CSM	COC	4GR	RGM
1W	6:26	6:35	6:41	6:45	6:55	7:02
Ⓐ 2W	6:56	7:05	7:11	7:15	7:25	7:32
3W	7:26	7:35	7:41	7:45	7:55	8:02
4W	7:56	8:05	8:11	8:15	8:25	8:32
5W	8:26	8:35	8:41	8:45	8:55	9:02
6W	8:56	9:05	9:11	9:15	9:25	9:32
7W	9:26	9:35	9:41	9:45	9:55	10:02
8W	9:56	10:05	10:11	10:15	10:25	10:32

The scheduler determines that 6:10 must be the starting time for 1E by subtracting out the 10 minutes the vehicle is at CBS for layover and by subtracting out the 36 minute running time it will take to get to CBS from RGM.



The eastbound trip schedule then proceeds in much the same way, maintaining a 30-minute headway and providing 10-minute layovers at **CBS** and 8-minute layovers at **RGM.**

Complete the partial schedule below for intermediate time points for eastbound trips 2E and 3E. Hint: remember the 30-minute headways. (Answers can be found on the following page.)

Route 32 - Eastbound
Weekday

Note how the order of time points changes with direction of travel (now eastbound)

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40					7:16
3E	7:10					7:46

Route 32 - Eastbound
Weekday

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40	6:47	6:57	7:01	7:07	7:16
3E	7:10	7:17	7:27	7:31	7:37	7:46
4E	7:40	7:47	7:57	8:01	8:07	8:16
5E	8:10	8:17	8:27	8:31	8:37	8:46
6E	8:40	8:47	8:57	9:01	9:07	9:16
7E	9:10	9:17	9:27	9:31	9:37	9:46
8E	9:40	9:47	9:57	10:01	10:07	10:16

No A.M. trip 9E is scheduled because it would arrive at CBS at 10:56 – 26 minutes past the 10:30 span of service plan.

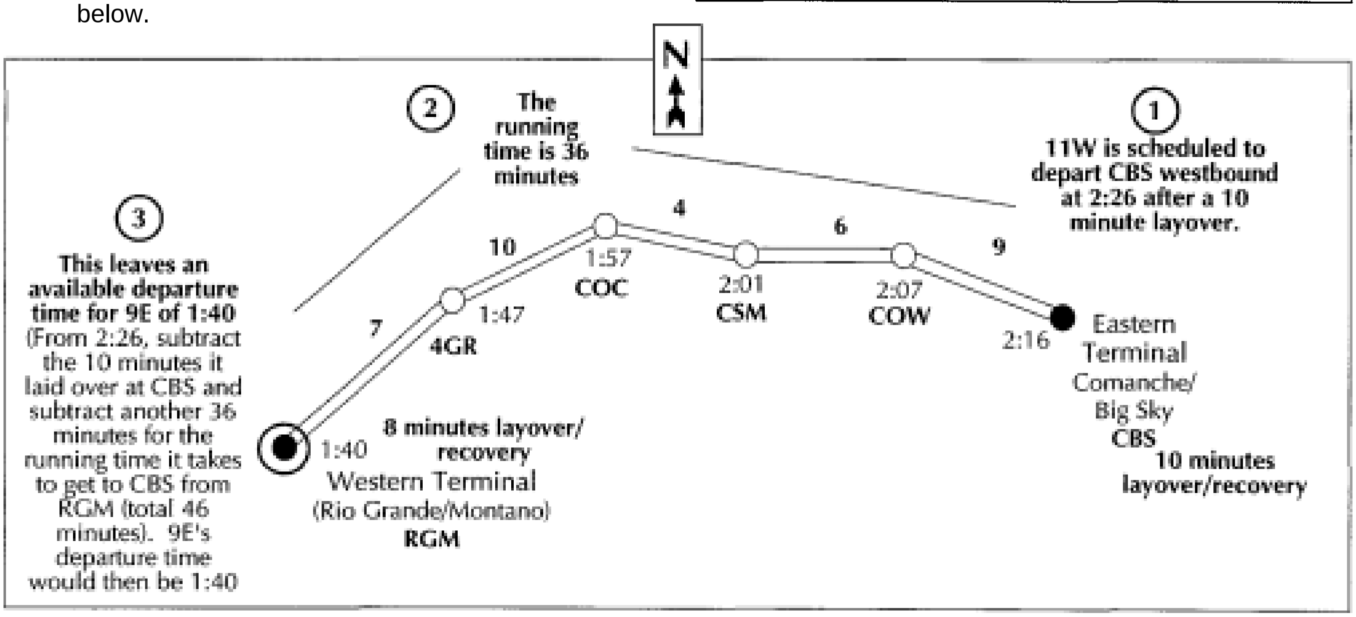
When does the first P.M. eastbound trip start?

The agency planned for P.M. service to start around 1:30 p.m. for Route 32 and run until approximately 6:30 p.m. The P.M. westbound schedule (shown reduced at right) shows the first P.M. westbound trip (9W) departing at 1:26 Ⓑ and 10W departing at 1:56. Ⓒ

Subtracting 46 minutes (10 minutes layover and 36 minutes running time) from either time results in an eastbound trip leaving earlier than the 1:30 service plan. Therefore, the first "hook" would come with a P.M. eastbound vehicle preceding 11W which leaves CBS at 2:26 Ⓓ as shown below.

Route 32 - Eastbound
Weekday

Trip No	CBS	COW	CSM	COC	4GR	RGM
9W	1:26 Ⓑ	1:35	1:41	1:45	1:55	2:02
10W	Ⓒ 1:56	2:05	2:11	2:15	2:25	2:32
11W	2:26 Ⓓ	2:35	2:41	2:45	2:55	3:02
12W	2:56	3:05	3:11	3:15	3:25	3:32
13W	3:26	3:35	3:41	3:45	3:55	4:02
14W	3:56	4:05	4:11	4:15	4:25	4:32
15W	4:26	4:35	4:41	4:45	4:55	5:02
16W	4:56	5:05	5:11	5:15	5:25	5:32
17W	5:26	5:35	5:41	5:45	5:55	6:02
18W	5:56	6:05	6:11	6:15	6:25	6:32



The P.M. eastbound trip schedule then proceeds in much the same way, maintaining a 30-minute headway, until the last P.M. trip arrives at **CBS** at 5:46.

Complete the partial schedule below for intermediate time points for eastbound trips 10E through 18E. (Answers can be found on the following page.)

Route 32 - Eastbound
Weekday

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40	6:47	6:57	7:01	7:07	7:16
3E	7:10	7:17	7:27	7:31	7:37	7:46
4E	7:40	7:47	7:57	8:01	8:07	8:16
5E	8:10	8:17	8:27	8:31	8:37	8:46
6E	8:40	8:47	8:57	9:01	9:07	9:16
7E	9:10	9:17	9:27	9:31	9:37	9:46
8E	9:40	9:47	9:57	10:01	10:07	10:16
9E	**1:40**	**1:47**	**1:57**	**2:01**	**2:07**	**2:16**
10E	**2:10**					**2:46**
11E	**2:40**					**3:16**
12E	**3:10**					**3:46**
13E	**3:40**					**4:16**
14E	**4:10**					**4:46**
15E	**4:40**					**5:16**
16E	**5:10**					**5:46**

Route 32 - Eastbound
Weekday

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40	6:47	6:57	7:01	7:07	7:16
3E	7:10	7:17	7:27	7:31	7:37	7:46
4E	7:40	7:47	7:57	8:01	8:07	8:16
5E	8:10	8:17	8:27	8:31	8:37	8:46
6E	8:40	8:47	8:57	9:01	9:07	9:16
7E	9:10	9:17	9:27	9:31	9:37	9:46
8E	9:40	9:47	9:57	10:01	10:07	10:16
9E	**1:40**	**1:47**	**1:57**	**2:01**	**2:07**	**2:16**
10E	**2:10**	**2:17**	**2:27**	**2:31**	**2:37**	**2:46**
11E	**2:40**	**2:47**	**2:57**	**3:01**	**3:07**	**3:16**
12E	**3:10**	**3:17**	**3:27**	**3:31**	**3:37**	**3:46**
13E	**3:40**	**3:47**	**3:57**	**4:01**	**4:07**	**4:16**
14E	**4:10**	**4:17**	**4:27**	**4:31**	**4:37**	**4:46**
15E	**4:40**	**4:47**	**4:57**	**5:01**	**5:07**	**5:16**
16E	**5:10**	**5:17**	**5:27**	**5:31**	**5:37**	**5:46**

How are trips in all directions combined onto one master schedule?

The typical convention for combining trips in both directions onto a master schedule begins with displaying time point locations horizontally along the top of the schedule (in each direction) with columns underneath. Trip numbers and times are also displayed horizontally.

For Route 32 shown on the next page, westbound trips are shown on the left-hand side and eastbound trips are show on the righthand side of the black vertical divider.

Now that all the trips are shown on the master schedule, how are vehicles assigned to make the trip?

Blocking is the process of assigning trips to vehicles (see Chapter 3).

During an effective blocking process, trips are hooked together and assigned to a vehicle in the most logical and efficient manner possible.

Completed master schedule for Route 32

Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
6:26	6:35	6:41	6:45	6:55	7:02							
6:56	7:05	7:11	7:15	7:25	7:32		6:10	6:17	6:27	6.31	6.37	6:46
7:26	7:35	7:41	7:45	7:55	8:02	A	6:40	6:47	6:57	7:01	7:07	7:16
7:56	8:05	8:11	8:15	8:25	8:32	M	7:10	7:17	7:27	7:31	7:37	7:46
8:26	8:35	8·41	8:45	8:55	9:02		7:40	7·47	7:57	8.01	8 07	8:16
8:56	9:05	9:11	9:15	9:25	9:32		8:10	8:17	8:27	8:31	8·37	8:46
9:26	9:35	9:41	9:45	9:55	10:02		8:40	8:47	8:57	9:01	9:07	9:16
9:56	10:05	10:11	10:15	10.25	10:32		9:10	9:17	9:27	9:31	9:37	9·46
							9:40	9:47	9:57	10.01	10 07	10·16
1:26	1:35	1:41	1:45	1.55	2:02							
1:56	2:05	2:11	2:15	2:25	2:32		1:40	1:47	1:57	2:01	2:07	2:16
2:26	2:35	2:41	2:45	2:55	3:02		2:10	2:17	2:27	2:31	2:37	2:46
2:56	3:05	3:11	3:15	3:25	3:32		2:40	2:47	2:57	3:01	3.07	3:16
3:26	3:35	3:41	3:45	3:55	4:02		3:10	3:17	3:27	3.31	3:37	3:46
3:56	4:05	4:11	4:15	4:25	4:32	P	3:40	3:47	3:57	4:01	4:07	4:16
4:26	4:35	4:41	4:45	4:55	5:02	M	4:10	4:17	4:27	4:31	4:37	4:46
4:56	5:05	5·11	5:15	5:25	5:32		4:40	4:47	4:57	5:01	5:07	5:16
4:26	4:35	4:41	4:45	4:55	5:02		5:10	5:17	5:27	5:31	5:37	5:46
5:56	6:05	6:11	6:15	6:25	6:32							

Review key points by answering these questions.

1) Specific arrival and/or departure locations that affect one or more trips along the route are called...

a) Intermediate time points c) Nodes

b) Controlling time points d) Relief points

2) Timed transfers require that vehicles converge upon a common location so that passengers can depart one vehicle to board another vehicle making trips on a different route. True or False

3) The same master schedule generally covers weekday, Saturday, Sunday and holiday service. True or False

4) Times for each time point are derived from the _ _ _ _ _ _ _ _ _ _ _ _ file.

5) Schedulers often think in terms of tying or hooking trips together. True or False

6) _ _ _ _ _ _ _ _ _ is the process of assigning trips to vehicles.

7) In the example below, complete trips 1W, 2W and 3W using the running times file at right below.

Trip #	**ABC**	**DEF**	**GHI**	**JKL**
1W	6:36			
2W	6:58			
3W	7:30			

Time point	A.M.
ABC	
DEF	9
GHI	6
JKL	7

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