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Transit Operator Guidelines for Transfer Policy Design

Final Report
June 1980

Service and Methods Demonstration Program

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16. Abstract

This report provides guidelines to aid transit operators in the design of policies to accommodate bus and/or rail transfers. A transfer policy may range from a complete set of operator actions involving vehicle routing and scheduling, transfer charges, information for passengers, and terminal facilities that in some way facilitates transfers, to a passive "do nothing" approach under which transferees might pay a second full fare, and possibly experience the full headway on the connecting route as transfer wait time. In either case, a policy for accommodating transfers reflects some set of objectives (explicit or implicit), and represents the selection of a program of action (or inaction) over many other alternatives.

Based largely on the analysis of information obtained from an examination of current or recent transfer practices at several transit properties in the United States presented in the comapnion report, State of the Art of Current Practices for Transit Transfers, the effects of eleven types of transfer policy actions are discussed. Situations or settings in which particular transfer policies can most beneficially be applied are identified. Combined with essential site-specific characteristics of a particular transit system, this document will assist the operator in choosing a transfer policy that best meets locally relevant goals and objectives.

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PREFACE

This study of transit transfer policies was prepared in the Boston, Massachusetts office of Charles River Associates Incorporated (CRA) for the Transportation Systems Center (TSC) of the U.S. Department of Transportation (DOT) under Contract Number DOT-TSC-1406, as part of the Service and Methods Demonstration (SMD) Program, sponsored by the Urban Mass Transportation Administration (UMTA). Michael Nelson served as CRA's Study Manager and Principal Investigator. Robert Casey of TSC served as Technical Advisor and Monitor for the study while Stewart McKeown was the UMTA Study Manager.

Many individuals contributed to the successful completion of this study. The CRA study team was supervised by Daniel Brand, CRA's Officer-in-Charge, who contributed much of the initial study design, as well as substantive reviews and revisions of study outputs. Michael Nelson directed the study on a day-to-day basis and was responsible for the preparation of this report. Michael Mandel conducted the interviews with transit professionals, performed most of the subsequent analyses, and contributed draft material throughout this report. Thomas Parody participated in initial study design and planning activities, while Jean Belding organized and edited this report. Other major CRA contributors included Mary Ann Buescher, Janet Fearon, Robert Scheier, and Kathryn Davenport, Publications, and Diane Kemski, secretarial.

Although CRA accepts full responsibility for the information presented in this report, the study would not have been possible without the cooperation and assistance of many other individuals. In particular, Robert Casey (TSC) provided many helpful observations and coordinated the reviews of the draft report conducted by UMTA staff and others. The innumerable and invaluable contributions of time and insights by the many transit professionals who participated in this study are also gratefully acknowledged.

METRIC CONVERSION FACTORS

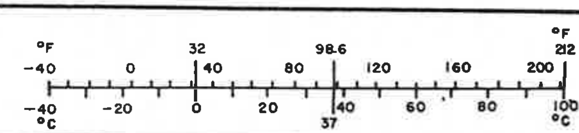
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Chapter 1
INTRODUCTION

1.1 Introduction

This report provides guidelines to aid transit operators in the design of transfer policies. A <u>transfer policy</u> consists of a set of operator actions involving vehicle routing and scheduling, transfer charges, information for passengers, and terminal facilities, which affects the movement of passengers between transit vehicles (bus and/or rail) as part of a continuing trip. Under ideal circumstances, transit would carry all users directly from their origins to their destinations without requiring a change of vehicles. However, given the geographic and temporal distribution of trips, such direct service is, of course, uneconomical for transit to provide. Therefore, operators must have some set of actions (a "transfer policy") with which to serve transferring passengers.

A transfer policy may range from a complete set of explicit provisions for vehicle routing, schedules, and so on, which in some way facilitates transfers, to a passive "do nothing" approach under which tranferees might pay a second full fare, and possibly experience the full headway on the connecting route as transfer wait time. In either case, a policy for accommodating transfers reflects some set of objectives (explicit or implicit), and represents the selection of a program of action (or inaction) over many other alternatives.

This document is intended to provide the transit operator with information about alternative transfer policies and their consequences. The material contained herein reflects current or recent transfer practice in the United States, making the guidelines that are suggested relevant to the working transit operator. Combined with essential site-specific characteristics of a particular transit system, this document will assist the operator in choosing a transfer policy which best meets his individual goals.

1.2 Sources of Guidelines Information

The information presented in this document is based largely on the analysis presented in a companion report.[1] That report documented the cost, ridersip, revenue, and user satisfaction consequences of alternative transit transfer policies involving buses, rail transit, and commuter rail. The principal data collection method utilized in that report was telephone interviews with knowledgeable transit professionals across the country.

For the portion of the study dealing with bus/bus transfers, discussions were carried out with a total of 34

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[1]Charles River Associates, State of the Art of Current Practices for Transit Transfers, Final Report prepared for Transportation Systems Center, U.S. Department of Transportation, May 1980.

transit operating authorities, while the study of bus/rail and rail/rail transfers entailed discussions with another 11 properties in 10 cities. Tables 1-1 and 1-2 list the properties that participated in the study. These properties were selected to ensure that many kinds of policies and operator attitudes in a variety of environments were included. Size, level of transfer charge, and use of timed transfers were important criteria in the selection process. Also particular care was taken to include properties that had undertaken innovative and interesting transfer policy initiatives.

The discussions with transit operators elicited informed opinions and the results of studies on specific properties concerning the effects of alternative transfer policies. In general, formal "before-and-after" studies of changes in transfer policies only have not been performed and are not available. Rather, participating transit operators drew on their experience to offer information and insights about the consequences of particular transfer policies in different settings. Based on this information, the current practices and consequences of each of 11 transfer policy components were described and analyzed in the state-of-the-art report. This operator guidelines report synthesizes and condenses these findings in a manner most conducive to transfer policy design.

1.3 Use of This Report

A transfer policy will have consequences for both operator and user. As specific transfer policies are implemented, the costs of providing service will vary. Also, as the characteristics of the service change from the consumers' viewpoint, there will be differences in the level of satisfaction obtained by transferring and nontransferring passengers alike. These may lead to changes in ridership and

Table 1-1

PROPERTIES PARTICIPATING IN STUDY OF BUS/BUS TRANSFERS

Albany, N.Y.
Atlanta, Ga.
Baltimore, Md.
Boston, Mass.
Brockton, Mass.
Buffalo, N.Y.
Charleston, W.Va.
Cleveland, Ohio
Columbus, Ohio
Denver, Col.
Duluth, Minn.
Eugene, Ore.
Everett, Wash.
Fresno, Calif.
Greenfield, Mass.
Hartford, Conn.
Indianapolis, Ind.
Jacksonville, Fla.
Knoxville, Tenn.
Lafayette, Ind.
Lawrence, Mass.
Lewiston, Maine
Memphis, Tenn.
New York City, N.Y.
Pittsburgh, Pa.
Portland, Maine
Portland, Ore.
Providence, R.I.
San Francisco, Calif.[1]
Springfield, Mass.[2]
Toledo, Ohio
Washington, D.C.
Westport, Conn.
Winston-Salem, N.C.

[1]San Francisco Municipal Railway
[2]Pioneer Valley Transit Authority

Table 1-2

PROPERTIES PARTICIPATING IN STUDY OF BUS/BUS AND RAIL/RAIL TRANSFERS

Atlanta, Ga.

Boston, Mass.

Chicago, Ill.

Cleveland, Ohio

Detroit, Mich.[1]

New York City, N.Y.

Philadelphia, Pa.

Pittsburgh, Pa.

San Francisco, Calif.[2]

Westport, Conn.

[1]Southeastern Michigan Transportation Authority (SEMTA).
[2]San Francisco Municipal Railway, Bay Area Rapid Transit, and Alameda-Contra Transit.

revenue, and ultimately to changes in operating deficits, which must be paid for by sources of revenue other than the fare box.

It is important for the operator to be able to identify potential transfer policies and evaluate them on the basis of their expected costs and benefits. Chapter 2 identifies and provides a brief description of available transfer policies and their current utilization by U.S. transit properties. Chapter 3 examines the demand-side (user-satisfaction, ridership, and revenue) consequences of alternative transfer policies, and includes a summary of key characteristics of transferring passengers. Supply-side (costs/operations) consequences are summarized in Chapter 4. Chapter 5 describes tradeoffs between the expected costs and benefits of implementing a particular transfer policy, constraints on implementation, and settings in which different transfer policies may be applied beneficially. In each chapter, bus/bus transfers are considered first. Important differences in consequences that arise when (rapid or commuter) rail is the connecting mode are then outlined.

There are several different ways this operator guidelines document can be used. First, of course, it can be read in its entirety as an action-oriented summary of the state-of-the-art report.[1] Alternatively, an operator may wish to concentrate on Chapters 2 and 5, to determine which transfer policies may have beneficial applications for his property, while using Chapters 3 and 4 as references to supply needed detail. Conversely, an operator may be interested in producing particular types of

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[1]Charles River Associates, State of the Art of Current Practices for Transit Transfers, Final Report prepared for Transportation Systems Center, U.S. Department of Transportation.

effects, and will therefore examine Chapters 3 or 4 in detail to identify policies that meet these goals. In all cases, the state-of-the-art report may be used as an appendix, to provide further detail.

Chapter 2
TRANSFER POLICY OPTIONS

2.1 Introduction

Transfer policies may be broken down usefully into basic types of operator actions, or transfer policy components (or options). This guidelines document examines 11 transfer policy components:

A. Routing Components

1. Distance between routes at transfer points;
2. Through-routing;

B. Scheduling Components

3. Schedule coordination;
4. Dynamic control of departure times at transfer points;
5. Timed transfers;
6. Schedule adherence on connecting routes;
7. Service frequency on connecting routes;

C. Pricing Components

8. Transfer charge;
9. Use of transfer slips;

D. Information Components

10. Provision of schedule information;

11. Marketing initiatives.

These transfer policy components do not exhaust the list of possible operator actions that affect transfers. The remaining ones (such as transit shelters, route restructuring, terminal facilities, and temporal and directional restrictions) were excluded from formal consideration at the outset of this study due to budget limitations. However, they are reviewed briefly in conjunction with several of the above components.

2.2 Routing Options

Routing options are principally concerned with spatial placement of routes and walking distances for transferring passengers. The two options in this category are the distance between routes at transfer points and through-routing.

Distance Between Routes at Transfer Points

Bus Transfers

A basic attribute of transferring is the walk required between vehicles. There may be only a few feet, or alternatively, passengers may have to walk several blocks to transfer. The greater the distance, the less utility the transfer has for the passenger. Transfer distances of 500 feet or more are not uncommon, and distances of up to 1,500 feet occur. Clearly, in situations such as these, measures to reduce the transfer walk may be productively employed.

Alternatives available to the operator affecting the spatial separation of routes at transfer points include:

- Baseline Alternative: Routing buses on the basis of operational and nontransferring demand considerations only;

- <u>Central On-Street Transfer Area</u>: Placing the termination points of all routes within one or two blocks of each other (when physically feasible);
- <u>Off-Street Transfer Facility</u>: Removing the buses and transferring passengers from the street, thus reducing spatial separation between buses and eliminating pedestrian obstacles;
- <u>Bus Transit Mall</u>: Designating a street upon which all or most routes coming into the CBD travel, so that all routes move past the same points, effectively reducing transfer distance to nearly zero;
- <u>Subfoci</u>: Collecting routes in the CBD into groups that terminate at the same spots. Routes can be grouped together if there are large numbers of transfers among them. Alternatively, routes can be grouped by service area. By clustering routes that service the same geographical area, and placing the terminal point on the <u>opposite</u> side of the CBD from the service area, the crossing or meeting of most route-pairs can be ensured, yielding short transfer distances; and
- <u>Grid Network</u>: Routing buses in a grid pattern, thus producing intersections between many or all nonparallel routes.

Table 2-1 lists examples of cities which use each of the active (nonbaseline) strategies for reducing spatial separation.

<u>Rail Transfers</u>

In contrast to bus/bus transfers, bus/rail and rail/rail transfers often involve vertical as well as horizontal separation between routes. Furthermore, the path between vehicles is not necessarily direct, as it usually is for bus/bus transfers. Transfer times range from near zero (in the

Table 2-1

SPATIAL SEPARATION STRATEGIES AND
SAMPLE CITIES FOR BUS TRANSFERS

Strategy	Example
Central on-street transfer point or area	Cleveland Lafayette Westport Albany
Off-street transfer facility	Brockton
Transit mall	Portland, Oregon Denver (planned)
Subfoci	Buffalo Fresno
Grid	Indianapolis Baltimore

Source: Operator interviews.

case of across-platform transfers between trains) to five minutes or more (between subway and surface bus). In some cases, where passengers must walk from one end of a lengthy station to the other, climb several flights of steps, and then walk another lengthy distance to a bus, elderly passengers in particular may experience transfer walk times of 10 minutes or more.

Given a fixed rail line, alternatives available to the operator relating to spatial separation at bus/rail or rail/rail transfer points include the following:

- Baseline Alternative: Building the rail facilities and then letting the buses stop at the nearest available curb space.
- Reduction of Perceived Vertical Distance: Adding escalators, elevators, and ramps for providing easy vertical movement for all transferring passengers.
- Reduction of Actual Vertical Distance: Bringing the buses up or down to the level of the rail platform by building bus access into the station itself.
- Off-street or On-street Bus Terminal Facilities: Reducing horizontal transfer distance by bringing buses together (as in the previous section) or at the same distance at some point closer to the rail station.
- Vertical Alignment of Bus and Rail Routes: Reducing horizontal transfer distance by placing bus stops directly over or under rail stations.
- Bus Ramps into Station: Reducing horizontal transfer distance by providing for across-platform transfers.

Table 2-2 lists examples of cities that use each of the active (nonbaseline) strategies for reducing spatial separation.

Table 2-2

EXAMPLES OF SPATIAL SEPARATION STRATEGIES FOR
BUS/RAIL AND RAIL/RAIL TRANSFERS

VERTICAL SEPARATION:

Reduction of Perceived Vertical Distance (e.g., Elevators and Escalators)

Washington, D.C.
Atlanta
San Francisco (BART)

Reduction of Actual Vertical Distance (i.e., Bus Tunnels)

Boston (Harvard Square)

HORIZONTAL SEPARATION:

Off-Street or On-Street Bus Terminal Facilities

Cleveland (Public Square)

Vertical (over/under) Alignment of Bus and Rail Routes

New York City (Stillwell Avenue)
Toronto
Washington, D.C.

Bus Ramps into Station

Boston (Ashmont)

Source: Operator interviews.

Through-Routing

Bus Transfers

Through-routing, also known as interlining, involves linking two routes so that the same vehicle travels on both routes. It eliminates transfers between the two routes, since a passenger can board a vehicle at a stop on one route and get off at a stop on the other without having to change vehicles. Many U.S. transit properties use through-routing, and some quite extensively.

Five types of through-routing are currently in use:

- "Classic" Through-Routing: Two separately identified routes share the same vehicles. The two routes must have the same headways and terminal points. Through-riding can either be free or cost the same as regular transferring. The termination points for the through-routed lines are usually in the CBD, but two routes may also be joined at an outlying terminus. Some systems note on their schedules which routes are paired.
- Single Route Through-Routing: This differs from classic through-routing only in that the two "halves" of the route are joined on a permanent basis, and are formally treated as a single route.
- Variable Through-Routing: This differs from classic through-routing in that buses are exchanged among multiple routes over the course of the day rather than just between pairs of routes. Extensive scheduling is needed, but it is not necessary that headways match on all routes.
- Trippers: Buses are through-routed at particular times of the day, usually during rush hour or to meet shift or school times. Extra buses must be added, or normal runs of regular routes must be extended.

- Overlap: This involves terminating a radial route on the opposite side of the CBD from which it came in, thus eliminating some distributor/feeder transfers downtown. Route lengths may be extended.

Table 2-3 gives examples of cities using various through-routing strategies.

Rail Transfers

Through-routing as described above is not applicable to rail transfers. In theory, a rubber-tired bus could be driven over an on-street route, and then, using a second set of (steel) wheels, traverse some line-haul rail segment in "dual-mode" operation. To date, however, conventional street buses have not been adapted successfully on a long-term basis for rail use.

The most significant option of this type relevant to rail transfers is route consolidation. Route consolidation involves the turning back at rail stations of bus routes that formerly traveled into the CBD. Route consolidation thus forces riders to transfer between bus and rail by making rail the only mode of transit access to the CBD. Table 2-4 illustrates the use of route consolidation by different U.S. transit properties.

2.3 Scheduling Options

This category is primarily concerned with the timing of vehicle movements and with the goal of reducing wait time for transferring passengers. This category considers five options: schedule coordination, dynamic control, timed transfers, schedule adherence, and service frequency. The last two of these options principally involve nontransfer-related costs and benefits, and therefore are only treated briefly.

Table 2-3

EXAMPLES OF CITIES USING VARIOUS BUS THROUGH-ROUTING STRATEGIES

Strategy	Example
Classic through-routing	Lafayette Memphis Toledo
Single route through-routings	Columbus Indianapolis
Variable through-routing	Everett Duluth
Trippers	Greenfield Fresno
Overlap	Baltimore

Source: Operator interviews.

Table 2-4

USE OF ROUTE CONSOLIDATION
BY SAMPLE RAIL TRANSIT PROPERTIES

Uses Route Consolidation
Boston
Atlanta
Washington

Does Not Use Route Consolidation
Detroit (commuter rail)
Boston (commuter rail)
Philadelphia
New York City

Source: Operator Interviews.

Schedule Coordination

Bus Transfers

Schedule coordination means adjusting schedules on routes to change the "offset" between times of arrival of the vehicles at transfer points. The purpose of schedule coordination is, of course, to reduce average waiting time. Typically, one bus is scheduled to arrive before another bus (rather than at the same time -- see timed transfers below). This means that people can transfer from the first bus to the second bus with minimal wait time and without disrupting the regular schedule. Hence, schedule coordination used alone is applied most beneficially to route pairs where the majority of transfers are in a single direction at any time.

Schedule coordination, as currently used, generally takes one of three forms:

- CBD Schedule Coordination: Used in situations where there is a strong directional flow of transfers through the CBD during peak hours. Typically, one bus is scheduled to arrive a few minutes before the other(s) in the mornings, with the order reversed in the evening since the flow of transfers is reversed.
- Trunk-Crosstown Coordination: The evening peak schedules of low-frequency crosstown buses are adjusted so that they arrive just after trunk line buses. This benefits passengers transferring from trunk to crosstown without seriously harming passengers transferring in the other direction, since trunk lines typically have high frequencies. The high frequency of trunk service makes it generally unproductive to use this option for inbound (morning peak) trips.
- Minor Schedule Coordination: Typically, implemented in response to the complaints of passengers on a particular

bus who are unable to make a connection to another route. The schedule of the particular run of the connecting route is adjusted to ensure that a transfer can be made.

Table 2-5 lists examples of properties using various schedule coordination strategies. It is important to note that no form of schedule coordination requires routes to have equal or evenly divisible headways, since it is not necessary that all runs meet. Likewise, operators have the option of publicizing or not publicizing their use of scheduling coordination.

Rail Transfers

Schedule coordination for bus/rail and rail/rail transfers is relatively uncommon for the following reasons (in descending order of importance):

- Rapid rail frequency is too high;
- Bus frequency is too high (especially during the day);
- Bus scheduling and rail scheduling are carried out independently;
- Bus routes cross multiple rail routes;
- Too many bus routes come into rail station; and
- Flexible (i.e., no fixed schedule) nature of rail operations in some settings.

Where schedule coordination occurs, it usually takes one of these forms:

- Rail to Bus Coordination: Used at outlying rail transit stations in the evening. Usually there are two or three train arrivals to every bus arrival, so not all trains are met. Occasionally bus headways are increased or adjusted to meet more trains, but the rail schedule is almost never affected. The bus is usually scheduled to leave four or five minutes after the rail is scheduled to arrive, and some sort of dynamic control (see below) is used to hold

Table 2-5

EXAMPLES OF PROPERTIES
USING BUS SCHEDULE COORDINATION STRATEGIES

Strategy	Property
CBD schedule coordination	Knoxville Winston-Salem Greenfield
Trunk-crosstown schedule coordination	Toledo Fresno
Minor schedule coordination	Pittsburgh Portland, Maine Boston

Source: Operator interviews.

the bus if the train is late. Overall, this option is similar to trunk-crosstown coordination for bus/bus transfers.

- Bus/Commuter Rail Coordination: Occurs in both the morning and the evening peak hours. Buses are typically "dedicated" to the commuter service, because schedule flexibility must be maintained to meet the relatively low frequency and reliability of commuter rail. In the morning, buses are usually scheduled to arrive at least five minutes before the train, since commuters would rather be early than late. In the evening, scheduling the buses to leave five minutes after the train gets in allows virtually all passengers to reach the bus. Again, dynamic control is often used, especially on the last commuter train, to ensure a meeting.
- Rail/Rail Coordination: Involves two rail vehicles on intersecting routes (as opposed to local and express routes running parallel on the same trackage). Typically, this option is utilized in the evening, when there are long headways. Sufficient advance must be allowed for people to walk between rail platforms.

Table 2-6 lists examples of properties that use each of these three types of schedule coordination involving rail.

Dynamic Control of Departure Times at Transfer Points

Bus Transfers

"Dynamic control" is defined as holding a bus beyond its scheduled departure time from a transfer point if it is known that a vehicle that is likely to have transferring passengers on board is approaching from another route. Such information can be conveyed by radio or by some other signaling device (e.g., headlights).

Table 2-6

EXAMPLES OF SCHEDULE COORDINATION ON RAIL PROPERTIES

<u>Rail-to-Bus Schedule Coordination</u>

San Francisco
Philadelphia
Cleveland
Chicago

<u>Schedule Coordination between Commuter Rail and Bus</u>

Westport (with Conrail)
Detroit

<u>Schedule Coordination between Intersecting Rail Lines</u>

Philadelphia

Dynamic control can be used by itself as a method to reduce average wait time for transferring passengers. Drivers of connecting buses may wait several minutes for the originating bus; this generally is contingent upon the ability to make up running time. To avoid excessive schedule disruption and overloads on the communications system, the use of this option is often not publicized on larger systems. It is most beneficially used in situations where schedule adherence is already low, since its use will not noticeably perturb an already perturbed system. Transfer points that produce user complaints and/or have long transfer wait times are also candidates for dynamic control as a stand-alone option.

In practice, dynamic control is most frequently used in conjunction with schedule coordination or timed transfers (see below), since the benefits from both of these options may be lost due to relatively minor disruptions to schedule adherence. In these cases, dynamic control helps guarantee low transfer times, and hence is an important factor in attracting ridership. For example, almost all properties that use timed transfers extensively use dynamic control, having late buses radio ahead and hold those buses at the transfer point that will be receiving passengers. Typical maximum holding time is five minutes, with longer times possible in the evening, when a premium is placed on guaranteeing that all people transferring will catch their buses. Table 2-7 lists examples of properties that use dynamic control alone and those that use it as an adjunct to schedule coordination or timed transfers.

Several dynamic control methods are technologically possible and potentially beneficial, though their use is not widespread at this time. These involve various versions of automatic vehicle monitoring (AVM) and the use of simple sensor systems. Other technological arrangements could also be

Table 2-7

EXAMPLES OF BUS PROPERTIES USING DYNAMIC CONTROL

Type of Dynamic Control	Property
Dynamic control alone	Portland, Maine Toledo Cleveland Indianapolis
Dynamic control with timed transfers or schedule coordination	Brockton Lafayette Knoxville Haverhill Eugene Memphis Fresno

Source: Operator interviews.

imagined, but the lack of current experience makes it impossible at this time to draw useful conclusions concerning their applicability or consequences.

Rail Transfers

Almost all rail properties use dynamic control to some degree at bus/rail transfer points, and a few use it at rail/rail transfer points as well. For bus/rail transfers, dynamic control is generally applied to bus movements only. There are three basic types of dynamic control that are applicable to rail transfers:

- Informal Holding of Buses: Without any special communications, the bus arrives at a train station where there are usually transferring passengers, and waits briefly for the train to arrive. Usual waiting time is one or two minutes. This option is most often applied in the evening and toward the last train trips of the day, when bus frequencies are low.
- Formal Meeting: The bus is formally scheduled to meet a particular train, and may hold for five to seven minutes or more for a late train. This option requires that bus operators take measures to locate late trains.
- Formal Holding: This option can be used for bus/rail or rail/rail transfers wherever there is a large spatial separation between vehicles. To avoid having the bus depart while passengers are in the process of transferring, a signaling device (e.g., light) is used to alert bus drivers when a train has arrived. Holding times of four to five minutes are common.

Table 2-8 gives examples of rail properties that use dynamic control.

Table 2-8

EXAMPLES OF RAIL PROPERTIES USING DYNAMIC CONTROL

Informal Holding
Washington
Boston
Formal Meeting
Westport
Detroit
San Francisco
Chicago
Formal Holding
Cleveland
Philadelphia (bus/rail and rail/rail)
San Francisco

Source: Operator interviews.

Timed Transfers

Bus Transfers

A timed transfer provides some degree of certainty that vehicles on different routes will meet at regular intervals to exchange transferring passengers. Timed transfers can be divided into four distinct types:

- Simple Timed Transfers: Two routes are scheduled and operated to guarantee that some or all buses on the routes will meet at the transfer point. Either layover (e.g., two to five minutes) or dynamic control at the transfer point is used to mitigate the effects of schedule unreliability and to ensure that the transfer can be made.
- Pulse Scheduling: Buses on all (or most) routes that meet at the major transfer point (in the CBD) are scheduled to arrive nearly simultaneously, hold until all buses have come in, and then leave together. The pulse frequency is typically 30 minutes throughout the day. Headways on different routes must be synchronized by altering route lengths and/or layovers. Layover time (up to five minutes) and dynamic control may also be used to mitigate schedule unreliability. The operator must provide suitable space and facilities to permit easy simultaneous interchange of passengers between buses.
- Line-ups: Line-ups are very similar to pulse scheduling in that buses on all (or most) routes that meet at the major transfer point are scheduled to arrive and depart in a manner that facilitates the simultaneous interchange of passengers between buses. However, service frequencies are usually lower (typically one-hour headways) and layovers at the transfer point are longer (five to ten minutes). This option may be viewed as a "relaxed"

version of pulse scheduling and is most often used on larger properties in the evening. Emphasis may be placed on guaranteeing that all passengers on the last trip of the day make their transfer.

- "Neighborhood" Pulse: The schedules of neighborhood circulator routes are coordinated to make travel within a sector of a large city easier. The actions required to do this are similar to those associated with pulse scheduling.

Table 2-9 gives examples of properties that use each of the four types of timed transfers for bus transfers.

Rail Transfers

Timed transfers involving rail as the connecting mode are much less common than timed transfers between buses. There are three reasons for this:

- Reluctance to adjust rail schedules;
- High frequency of most rapid rail lines; and
- Larger transfer distance inherent in most transfers involving rail (except across-platform transfers).

However, there are cases where bus/rail timed transfers have been implemented. These include the following:

- Commuter Rail/Bus: Occurs when buses serve as feeders to commuter rail, but reverse passenger flows also occur.
- Rail Transit/Bus: Occurs when trains to special destinations (e.g., airports) require connecting buses.
- Bus Timed Transfer plus Rail: Occurs when rail is involved in a bus pulse or line-up. The trains may not actually "pulse" with the buses, but there is at least some schedule coordination between the bus pulse and the train arrival, which allows for low transfer times in at least one direction.

Table 2-10 gives examples of rail properties that have utilized timed transfers.

Table 2-9

EXAMPLES OF BUS PROPERTIES USING TIMED TRANSFERS

Type of Timed Transfer	Property
Simple timed transfers	Albany Washington, D.C.
Pulse scheduling	Fresno Lafayette Brockton Westport Lewiston Haverhill
Line-ups	Knoxville Portland, Oregon Columbus Memphis Toledo Albany
Neighborhood pulse	Denver Portland, Oregon

Source: Operator interviews.

Table 2-10

EXAMPLES OF RAIL PROPERTIES USING TIMED TRANSFERS

<u>Commuter Rail/Bus</u>

Westport

<u>Rail Transit/Airport Bus</u>

New York City

<u>Bus Timed Transfer Plus Rail</u>

Philadelphia
Cleveland

Schedule Adherence on Connecting Routes for Bus and Rail Transfers

Schedule adherence is an important aspect of overall level of service on transit properties that affects all riders (transferring and nontransferring) on the system. From the point of view of the transferring rider, reliability of the connecting service significantly affects the usefulness of the transfer. Therefore, schedule adherence must be examined as part of a transfer policy.

There are several major causes of schedule adherence problems, including traffic congestion, variations in passenger loads, mechanical failure of vehicles, and interference at grade crossings. A variety of strategies are available to remedy "bunching" and less severe schedule disruptions, such as traffic engineering, headway checking at time points, skip-stopping, and insertion of spare buses. In general, the nontransfer-related effects of these strategies are the most important determinants of their application. However, as outlined above, schedule adherence is an important factor in the implementation of options such as timed transfers, and therefore is an important consideration in transfer policy design.

Service Frequency on Connecting Routes

Bus Transfers

Service frequency, like schedule adherence, is an important component of transit level of service having consequences far beyond its impact on transfers. Given good schedule adherence, increasing the frequency of service on a connecting route should decrease the transfer wait time. Typically, however, operators raise or lower service frequency in response to nontransfer-related factors. The exceptions to this rule arise when other transfer components such as timed transfers, through-routing, and schedule coordination are implemented, since headways must be synchronized between routes. Even in these cases, however, the headway adjustments currently made are usually not large.

Rail Transfers

Rail service frequency is almost never changed for the purpose of implementing a particular transfer policy option. There are several reasons for this. First is the typically high frequency of rapid rail, which tends to make other transfer policy scheduling options unnecessary when rapid rail is the connecting vehicle. Second is the difficulty of changing headways, especially on systems where there is much interdependence of schedules on different routes. Under these circumstances, each frequency change would require a rescheduling of the entire system. Finally, if the buses and trains are scheduled by different authorities, coordination between the two groups regarding transfer connections may be difficult or impossible.

2.4 Pricing Options

The third category of transfer options is related to pricing and financial considerations. The transfer charge itself is the most important option of this type. However, closely connected with the level of transfer charge is the method of granting reduced fare transfers (e.g., use of transfer slips), which has its own impacts.

Transfer Charge

Bus Transfers

The transfer charge is the amount of money, over and above the basic fare, that a passenger pays to transfer to a second bus. Most transit properties currently have a zero or $0.05 transfer charge. Other transfer charge levels are comparatively rare. In particular, very few properties have full fare transfers. Table 2-11 gives examples of cities with a nonzero transfer charge.

There is a variety of reasons for setting the transfer charge at a particular level. These include the following (in approximate order of importance):

- Historical precedent;
- Transfer abuse (selling or giving away transfers);
- Political/equity (including encouraging or at least not penalizing transfers);
- Raising revenue;
- Public relations;
- Decreasing bus running time by eliminating transfer charge payment; and
- Others (e.g., lack of system to administer reduced fare transfers).

Table 2-12 shows examples of properties citing various reasons for their level of transfer charge.

Rail Transfers

Bus/rail and rail/rail transfer charges are considerably less uniform across different properties than bus/bus transfer charges. There are full fare transfers, half fare transfers, dime transfers, nickel transfers, and free transfers. Tables 2-13 and 2-14 provide detailed bus/rail and rail/rail transfer charge information for a number of rail properties.

The principal reasons for setting the level of the bus/rail transfer charge are the following:

- Historical/institutional/political;
- Raising revenue;

Table 2-11

EXAMPLES OF BUS PROPERTIES WITH NONZERO TRANSFER CHARGES

Transfer Charge (Cents)	Properties
5	Toledo Winston-Salem Knoxville Providence Lafayette Memphis Baltimore Buffalo Indianapolis
10	Springfield, Mass. Pittsburgh
25	Jacksonville Boston New York City[1]
30	Lawrence

[1]Transfers are free at many transfer points.

Source: Operator interviews.

Table 2-12

REASONS CITED FOR TRANSFER CHARGE

Reason	Example of Properties Citing Reason
Transfer abuse	Toledo Boston Lafayette Baltimore
Political/equity	Hartford Columbus Denver Lewiston
Raising Revenue	Jacksonville Boston Pittsburgh Baltimore
Decrease bus running time	Fresno
Lack of transfer administration system	Lawrence

Source: Operator interviews.

Table 2-13

BUS/RAIL AND RAIL/RAIL TRANSFER CHARGE
(Excluding Commuter Rail)

Urban Area	Bus to Rail Transfer Charge (Cents)	Rail to Bus Transfer Charge (Cents)	Base Fare (Cents)
Atlanta	0	0	25
Boston	25	25	25
Chicago	10	10	50
Cleveland	10[1]	0	25 (bus)
New York	50[2]	50[2]	50
Philadelphia[3]	5	5	45
Pittsburgh	10	10	50
San Francisco	25	0[4]	25
Washington, D.C.	40	0	40

[1]Transfer charge only applies from local bus to rail.

[2]Bus/rail transfers are free at three transfer points where bus has replaced rail.

[3]Transfers between Red Arrow and City Transit Divisions are $0.30.

[4]On AC Transit, free tranfers are issued at rail station. On Muni, rider pays $0.25 at rail station for two-way ticket.

Source: Operator interviews.

Table 2-14

COMMUTER RAIL/TRANSIT TRANSFER CHARGE

Urban Area	Commuter Rail to Bus or Rail Transit Transfer Charge/(Cents)	Bus or Rail Transit to Commuter Rail Transfer Charge (Cents)	Comments
Boston	Full	Full	
Detroit	0	0	Feeder bus is free with two-part rail transfer.
New York	Full	Full	
Philadelphia	0-10	0-10	Various transfer charges between commuter rail and bus.
	Half-fare	Full	Transfers from Lindenwold line.
Pittsburgh	10	Full	
Westport	Full	Full	Conrail commuter trains.

Source: Operator interviews.

- Abuse; and
- Equity.

Table 2-15 shows examples of reasons cited by different rail property operators for the level of their transfer charge.

Transfer Slips

Bus Transfers

Transfer slips are the principal method for offering reduced fare transfers. These slips identify a passenger who has already boarded a bus on his/her trip and (within stated time and directional limitations) is entitled to board subsequent vehicles at reduced fare. Clearly, issues related to transfer slips are only relevant if the operator wishes to charge less than full fare for transfers.

Most properties providing free or reduced fare bus/bus transfers use conventional transfer slips, but some use daily passes or, in one case, no transfer slips at all to grant reduced fare transfers. In the last case, a small property (Haverhill, Massachusetts) with only three buses is on a pulse schedule, so all buses are at the transfer point at the same time, and the bus drivers are able to see whether people are transferring from the other buses.

Rail Transfers

Several methods are available for reduced fare bus/rail transfers. These methods range from fare-paid areas that the bus enters, to magnetic cards, to two-part transfers good for inbound and outbound bus trips. Table 2-16 lists the methods presently utilized by many rail properties, together with examples of those cities that use them, and the reasons for their use.

Table 2-15

REASONS CITED FOR BUS/RAIL AND RAIL/RAIL TRANSFER CHARGE

Historical/Institutional/Political

Atlanta
New York
San Francisco
Washington

Raising of Revenue

Philadelphia
Boston
New York
Pittsburgh

Transfer Abuse

Philadelphia
Boston

Equity

Atlanta

Table 2-16

BUS/RAIL TRANSFER METHODS

Method	Used By	Reason for Using
Transfer slip issued by bus driver or change booth clerk, collected by same	Cleveland, Philadelphia, Chicago	Simple to implement (similar to procedure for bus/bus transfers)
Commuter rail pass good on transit	Detroit	Simple
Two-part transfer slip (either free or paid) issued on train or in station, one part good for bus trip away from rail and other part good for bus trip toward rail	Detroit, San Francisco	Primarily for institutional reasons
Transfer to bus dispensed from machine in rail station at destination	San Francisco (AC Transit)	Primarily for institutional reasons
Transfer to bus dispensed from machine at originating rail station	Cleveland, Atlanta, Philadelphia, Washington	Avoids abuse
Direct paid area for bus/rail transfers	Atlanta, New York	Simplest procedure
Magnetic card for transfer to rail obtained on bus	Atlanta	Permits bus to rail transfers
Rail to bus transfer obtained from original bus driver	Atlanta	For people entering rail in paid area

As stated in Chapter 1, several issues related to transfer slips are not included in this study due to budget limitations. The effects of varying the temporal and directional restrictions on transfers are not analyzed, nor are the internal management and administrative procedures associated with controlling transfer slips. Indeed, a review of the different kinds of "hardware" that can be used for bus/bus transfers, i.e., different types of transfer slips, magnetic cards, and so on, is a potential major study by itself.

2.5 Information Options

The fourth and last category of transfer policy components consists of options primarily concerned with the dissemination of transfer information. The basic option of this type is the provision of information about existing services, including (but not limited to) schedules, routing, and other elements of the transfer policy. The second option of this type, marketing initiatives, can increase the level of factual understanding of system operations and change the users' overall perception of transit.

Schedule Information

Bus Transfers

The provision of schedule information is an option of broad general interest in transit. Schedule information useful for transferring can be provided either at the transfer point or prior to the start of the transit trip. At the transfer point, transit properties can supply or post printed schedules, and/or disseminate information about whether the connecting bus is late. Prior to the trip, sources of information include printed schedules (which may include information on transfer points, time points, and "best connecting vehicles"), and telephone information systems. Schedules can also provide information on the other components of the transfer policy (e.g., through-routing, dynamic control, schedule coordination, timed transfers). In general, most properties only indicate the transfer charge and procedure for using transfer slips on their schedules, and almost never indicate the use of dynamic control or schedule coordination.

Rail Transfers

All schedule information options reviewed in the previous section for bus/bus transfers can be applied to bus/rail and rail/rail transfers as well. However, there are some methods of schedule information provision that are utilized for bus/rail and rail/rail transfers, and not usually for bus/bus transfers. These include providing a map in the rail station to show where buses stop, use of the loudspeaker system to provide information about late trains, and the posting of signs at rail stations to aid passengers traveling between vehicles.

Information can also be provided before the start of the transit trip. Examples include the following:

- Best connecting vehicle, either for bus/rail or rail/rail transfers (Cleveland, Philadelphia); and
- Best transfer point to utilize when traveling to a specific destination (Philadelphia).

Once again, use of options such as dynamic control and schedule coordination is typically not publicized.

Marketing Initiatives: Bus and Rail Transfers

Transfer-related marketing initiatives by the transit operator can take one of three general approaches:

- Focus completely on transfers. This can occur when the transfer policy includes some distinctive feature such as pulse scheduling, a universal transfer valid between carriers, dynamic control, or minor schedule coordination. Marketing initiatives of this type are comparatively rare.
- Participate in a broader marketing effort. For example, case of informational brochures, general schedule distribution, and transit fare prepayment plans may describe or indirectly promote free transfers.
- Utilize transfers incidentally to market other aspects of the transit system. For example, transfer slips can be used as daily passes, or in promotions in which retail establishments offer their customers return fares in exchange for transfer slips.

This concludes the description of the 11 transfer policy components included in this study. These options and their variations and combinations are analyzed in detail in the following chapters.

Chapter 3
DEMAND-SIDE CONSEQUENCES OF ALTERNATIVE TRANSFER POLICIES

3.1 Introduction

The demand-side consequences of a transfer policy can usefully be described in terms of user satisfaction, ridership, and revenue. User satisfaction depends on the transfer level of service, the attributes of which are listed in Table 3-1. Changes in user satisfaction will usually lead to ridership changes, by attracting additional person-trips to the system and/or inducing present transit users to transfer more. Ridership changes that do occur will generally lead to revenue impacts as well.

In Section 3.2, typical characteristics of transferees on different properties are outlined. In the remainder of the chapter, the user satisfaction, ridership, and revenue consequences of each of the 11 transfer policy options are presented. Consequences for bus/bus transfers are addressed first, with any differences associated with bus/rail and rail/rail transfers covered in a subsequent section.

Table 3-1

TRANSFER LEVEL OF SERVICE ATTRIBUTES

Considered in Study

- Walking time/distance required to transfer (horizontal or vertical distance)
- Transfer versus no transfer (i.e., by through-routing vehicles)
- Average wait time for connecting vehicle
- Variance in wait time (transfer reliability and probability of making connection)
- Transfer charge (pricing transfers equal to or less than full fare)
- Ease of comprehension of transfer policy (for above attributes)

Not Considered in Study

- Temporal and directional limitations on nonfull fare transfers
- Transfer amenities (e.g., shelter from elements, physical security)

3.2 Transfer Characteristics

There are several characteristics of transfer demand that are relevant to transfer policy design on any particular property. These include the following:

- The percentage of riders who transfer;
- Their socioeconomic and trip purpose characteristics;
- Transfer point locations; and
- Directional and temporal characteristics.

While this information is not always easily obtainable, general conclusions can be drawn from analysis within and across specific sites.

Bus Transfers

For the purposes of this analysis, the transfer rate is defined as the percentage of bus person-trips that involve transfers between buses. Persons who utilize a fare prepayment device will count as transfers, while persons who transfer more than once in the course of a trip are not double-counted. This definition of transfer rate is designed to measure the proportion of riders who would be affected by a change in transfer policy.

The transfer rate (TR) is not necessarily an easy number to calculate. The following are examples of methods that have been used to calculate it:

1. The total number of person-trips (P) and the number of person-trips that involve transfers (PT); TR = PT/P.
2. Total boarding riders (R), and the total number of transfers (T), (under the assumption that there are few trips involving double transfers); TR = T/(R - T).
3. Total boarding riders (R), number of person-trips involving a single transfer (T_1), and the number of person trips involving a double transfer (T_2);
   $TR = (T_1 + T_2)/(R - T_1 - 2T_2)$.

Other approaches could also be used to derive the transfer rate. Each approach attempts to calculate the transfer rate as defined above. The choice of an approach is determined locally by the available data.

The transfer rates on most properties tend to lie in a range around 20 percent, though transfer rates as low as 5 percent and as high as 50 percent have been observed. For the most part, however, the bus/bus transfer rate lies between 10 and 35 percent.

Transfer rates seem to be correlated with the transfer policy used. As shown below, properties that currently use timed transfers extensively have an average transfer rate of 28 percent, while properties that do not use timed transfers extensively have an average transfer rate of approximately 18 percent.

	Transfer Rate (Percent)		
	Average	Low	High
Properties that used timed tranfers extensively	28	18	50
Properties that do not used timed transfers extensively	18	5	33

It should be noted, though, that the causal relationship here is not clear. Timed transfers may increase the transfer rate through a reduction in transfer time but conversely, the existence of travel patterns that result in a high transfer rate may make it more likely that a property will institute timed transfers.

Another policy option that seems to be loosely correlated with bus/bus transfer rates is charging for transfers. Properties that do not charge for transfers have an average transfer rate of approximately 22 percent, while properties that do charge for transfers have an average transfer rate of approximately 18 percent.

	Transfer Rate (Percent)		
	Average	Low	High
Properties that do not charge for tranfers	21.5	5	37
Properties that do charge for transfers	17.5	5	50

Once again, there is no obvious causal relationship. Having no transfer charge may attract new transfers, but origin/destination patterns that result in a high bus/bus transfer rate may also lead to a zero transfer charge for political/equity reasons.

One transfer option that has an obvious direct effect on the transfer rate is through-routing. Individuals who ride through on the same bus traveling two bus routes are not counted as transfers. Therefore, properties that have no through-routing have a higher average transfer rate than those properties would if they instituted some form of through-routing.

The size of the property also has a large influence on the overall transfer rate. The average bus/bus transfer rate in large cities appears to be essentially the same as the average transfer rate in small cities (20.3 percent versus 19.5 percent). However, when the properties that currently use timed transfers extensively (all of which are small) are separated from the remainder of the small properties, the relationship between size and transfer rate becomes clearer.

	Transfer Rate (Percent)		
	Average	Low	High
Large properties	20.3	10	33
Small properties that do not use timed transfers	11.8	5	20
Small properties that do use timed tranfers	30.5	18	50

It is reasonable to assume that higher transfer rates on large properties are due generally to the increased dispersion of origins and destinations and more frequent connecting service found on large properties. However, there is no reason why a particular small property cannot have a high transfer rate due to dispersed origins and destinations or good connecting service, as shown above. Not surprisingly, several properties, both small and large, have found that increased employment and shopping outside of the CBD was followed by increased transferring.

While the aggregate transfer rate is a useful descriptor of a bus system, the pervasive importance of specific origin/destination patterns described above makes it essential that transfer flows be examined in greater detail before transfer policies are designed. Transfer patterns can be classified productively into three major types:

- CBD transfers, made by a rider traveling through the CBD to travel across town;
- Line haul transfers, which involve a transfer from a crosstown route to a trunk line or vice versa to get to or from downtown; and

- <u>Distributor/feeder transfers</u>, for which one leg of the trip is much shorter than the other leg (e.g., a rider who takes a bus into the CBD, and then transfers to another bus for a short ride).

A transferee in each of these categories may respond differently to any given transfer policy component. For instance, a short walk might be used to substitute for distributor/feeder transfers so transferees of this type may be highly sensitive to changes in transfer level of service.

Transferees tend to have distinct socioeconomic and demographic characteristics. For example, low-income riders transfer more than higher-income riders. A reasonable rule of thumb is that riders with household incomes below $15,000 have a transfer rate about one and one-half times as high as riders with household incomes above that figure. Several explanations can be advanced for this relationship. First, patterns of employment may result in white-collar jobs being located in the CBD, so that transferring is not necessary to reach them. Along similar lines, suburbs and outlying areas may have express routes directly into the CBD. The third and most likely explanation is that higher income individuals are more likely to have a car available to them, and are thus less likely to accept the burden of a transit trip that requires transferring.

A second group with above average rates of transferring is youth. This can be attributed to their lack of an available auto, the relatively low value that they may place on time, and the relatively low deterrent effect of walking that may be associated with transferring. Elderly people, on the other hand, tend to have a lower transfer rate than other riders, perhaps because of the effort involved in changing vehicles associated with transfers. In fact, whether transfer is necessary is an extremely important factor to elderly people in travel choice decisions.

From the survey data available, the transfer rates for male and female riders show no significant differences. However, users who ride infrequently are more likely to transfer than those who ride frequently. This implies either that low frequency trips, such as shopping and social-recreational trips, are more likely to involve transfers, or that the onerous nature of transfers tends to discourage transit riding. To the degree that the second hypothesis holds, easing transferring will increase ridership.

Rail Transfers

The intermodal rail transfer rate is defined as the percentage of rail riders whose trip has involved or will involve a transfer to another transit mode (streetcars, buses, cable cars, trolley buses). If bus is the only other transit mode, then this number will be known as the bus/rail transfer rate. As was the case for bus transfers, many methods can be used to calculate this statistic.

Table 3-2 shows intermodal rail transfer rates for various cities. Most rail transfer rates are in the 40-70 percent range, except for New York City (16 percent), which can be explained by the extensive rail coverage in Manhattan and parts of Brooklyn that allows passengers to walk to and from the subway.

In each of the following sections, the demand-side consequences of individual transfer policy components are examined in detail.

Table 3-2

INTERMODAL RAIL TRANSFER RATES

Property	Year	Intermodal Rail Transfer Rate	Transit Modes Available	Comment
Atlanta	Projected	67	Bus	
Boston	1977	48	Bus, Streetcar	
Chicago	1978	70	Bus	
Cleveland	1976	50	Bus, Light Rail	Transfer rate for heavy rail
New York City	1966	16	Bus	
Philadelphia	1979	60	Bus, Light Rail	Transfer rate for heavy rail
San Francisco	1974	27	Bus	Transfer rate for passengers using stations served by AC Transit
Washington	1978	42	Bus	

Source: Based on figures obtained in operator interviews.

3.3 Routing Options

Distance Between Routes at Transfer Points

Bus Transfers

As transfer walk distance between two routes is decreased, the satisfaction of transferring riders increases due to the following factors:

- Decreased physical effort of walking;
- Fewer encounters with "pedestrian obstacles";
- Increased comprehensibility of transfer system; and
- Decreased probability of seeing connecting bus leave transfer point.

These elements tend to affect elderly passengers, shoppers, and infrequent riders more than other users.

Reduction of transfer walk time will have a greater effect on user satisfaction than an equal reduction of transfer wait time or in-vehicle line-haul time. This is supported by the observed preference of passengers to transfer at the point of closest approach between two routes, rather than at some other point that, on essentially parallel routes, might produce significantly lower total travel times. Available information also indicates that if two routes are separated by three or four blocks, many people will take an intermediate bus if one is available (even if it leads to an additional transfer, higher total transfer wait time, and possibly higher cost).

Out-of-vehicle time, in general, is believed to be much more onerous than in-vehicle time, and walk time is likely to be the most onerous form of out-of-vehicle time. Therefore, at a transfer point where routes are widely separated, reduction of the transfer distance may yield a substantial increase in transferring, and a small but significant increase in overall ridership (e.g., 5 percent). Under many circumstances, the additional revenue generated by these passengers may exceed the extra operating costs associated with the reduction of spatial separation (see Chapter 4).

Rail Transfers

In general, bus/bus transfers are more onerous than bus/rail transfers, which are in turn more onerous than rail/rail transfers. This is due to both the shorter headways found on rapid rail lines and the amenities provided by rail facilities, and tends to reduce the demand-side gains that can be expected from reducing the transfer distance for rail transfers. On the other hand, some market segments, such as the elderly and handicapped, may be discouraged from using transit altogether by vertical transfer distance. Therefore, strategies to reduce the separation between routes may produce significant user benefits for at least some rail transferees.

Through-Routing

Bus Transfers

Through-routing affects user satisfaction by eliminating the need to transfer for some passengers. This is most beneficial for elderly riders and shoppers for whom movement between vehicles causes the greatest disutility. Through-routing will also increase the satisfaction of other transferees by eliminating out-of-vehicle transfer wait time.

Changes in ridership due to through-routing are difficult to quantify because through-riders do not usually use transfer slips, and operators cannot determine their numbers with consistency and accuracy. Based on limited data, indications are that even on properties that design their through-routes around travel patterns, the increase in total ridership on those routes will not exceed 7 or 8 percent. For properties that through-route solely to simplify scheduling and so on, the number of new riders would tend to be smaller. In addition, properties which through-route for such "operational" reasons may not publicize the through-routing for fear that it would limit their flexibility to switch route pairs if circumstances change. This further reduces potential ridership increases and results in a slow attainment of equilibrium after a through-routing implementation as awareness of the new linkage spreads slowly by word-of-mouth. The revenue consequences of these ridership changes depend on whether through-riders must pay a transfer charge or not.

Different variations of through-routing have unique consequences:

- Single Route Through-Routing: Most easily comprehensible by users. Unlinking two halves can have a major negative impact on ridership and revenue.
- Variable Through-Routing: Raises user satisfaction for those people who do not have to travel at a specific time, such as elderly and shoppers. Increases in ridership and revenue depend on the ability of the potential rider to determine which runs are linked (e.g., using the telephone or printed schedules).
- Trippers: Ridership and revenue may increase from work trips, but not from school children who tend to be captive riders.

Rail Transfers

Route consolidation, the opposite of through-routing, affects user satisfaction in several ways. On the negative side it adds the need to transfer where none existed before, requiring individuals to ride rail who might prefer through bus service (e.g., elderly). On the positive side, bus-to-rail transfers are generally less onerous than bus-to-bus transfers, and average trip time may be shortened due to the typical speed advantage of rail over local bus. A pivotal factor in determining the magnitude of the decrease in user satisfaction caused by bus route consolidation is the quality, reliability and area coverage of the rail line. However, in general, bus route consolidation can only decrease ridership and revenue since it reduces the choices available to potential transit users.

3.4 Scheduling Options

Schedule Coordination

Bus Transfers

Schedule coordination can produce significant user satisfaction, ridership, and revenue effects. However, it is necessary to consider each type of schedule coordination separately.

- CBD Schedule Coordination: Raises satisfaction of passengers traveling in direction of transfer flow imbalance by reducing transfer time. Overall ridership and revenue gains on coordinated routes of 3 or 4 percent are not unreasonable. However, larger increases would be rare because the principal beneficiaries of CBD schedule coordination tend to be low-income captive transferees who are relatively insensitive to service quality changes.[1]

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[1]It should be noted, though, that particular cities may exhibit latent demand for traffic through the CBD from higher-income areas. Schedule coordination would then be a way to raise the level of service and to attract new riders and revenue from this market.

- Trunk-Crosstown Coordination: Increases user satisfaction for riders transferring from the trunk to the crosstown, especially if the crosstown buses that are coordinated are publicized. Riders in the other direction are not severely affected if the trunk line has high service frequency. Overall ridership and revenue on the coordinated routes can be expected to increase by roughly 2 percent. This is approximately half of the increase produced by CBD schedule coordination because trunk-crosstown schedule coordination is only applied to the outbound direction.
- Minor Schedule Coordination: Increases user satisfaction substantially for the riders who previously were just missing their bus, especially where there are long headways on the connecting route. However, because the increase in user satisfaction is restricted to a particular run, there is not necessarily a significant direct gain in ridership or revenue. Nevertheless, this type of response of the service provider to user complaints may be a particularly valuable type of marketing tool to produce longer-run changes in consumer attitudes and ridership.

Rail Transfers

The consequences of schedule coordination involving rail transfers also depend heavily on the specific option chosen.

- Rail-to-Bus Schedule Coordination: Affects user satisfaction, ridership, and revenue much the way trunk-crosstown coordination does for bus transfers. An increase of 2 to 3 percent in total ridership on the bus route during the period when the coordination is in effect is reasonable to expect.

- Bus/Commuter Rail Coordination: User satisfaction should increase with schedule coordination. This effect will be more pronounced in the evening than in the morning since auto pickup may be undesirable as an egress mode, and uncoordinated meetings between bus and commuter rail may offer an unacceptably low quality of service.
- Rail/Rail Coordination: User satisfaction, ridership, and revenue can be expected to be affected somewhat if there is a significant directionality in transfer flow. However, unless conditions in the rail station are such that transfer wait time is onerous, or unless headways are significantly greater than ten minutes, the small drop in average transfer wait time will produce only minor user benefits.

Dynamic Control of Departure Times at Transfer Points

Bus Transfers

Dynamic control has several distinct effects on user satisfaction. Riders transferring to the controlled route experience substantial benefits, as the longest possible transfer waits are eliminated. However, dynamic control may have some small negative effect on those individuals who board the controlled route after the transfer point or who are already on the bus. If the route or system has serious schedule adherence problems (due to a snowstorm, for instance) dynamic control will have virtually no negative effects at all. Overall, the net effect of dynamic control on ridership is likely to be small, with the possible exception of cases where it is used to enhance other options, such as timed transfers.

Rail Transfers

Dynamic control again increases user satisfaction by eliminating those occasions where transferring passengers just miss their bus and have to wait the full bus headway. Again, however, the user satisfaction of riders boarding the bus "downstream" may be adversely affected by delays of five minutes or more. For buses that are "dedicated" to distributing commuter rail riders in the afternoon, these "downstream" effects may not be important. Overall, dynamic control of bus/rail and rail/rail transfers (like bus/bus dynamic control) tends to be viewed as a public relations measure with only minor direct ridership and revenue consequences.

Timed Transfers

Bus Transfers

User satisfaction for transferring passengers increases significantly whenever timed transfers are used. The key factors which influence the degree of user satisfaction associated with timed transfers are as follows:

- Reliability of connections;
- Comprehensibility of system;
- Frequency of service; and
- Coverage of routes.

Reliability is important since passengers need to be sure of making their connection almost every time, since one bad experience can counteract the effects of a large number of good ones. Comprehensibility of the system (and hence user satisfaction) is increased by timed transfers, since riders need not worry about when the connecting bus will arrive. The effect of frequency is essentially inverse, because the lower the route frequency, the larger the change in user satisfaction induced by timed transfers. The final factor, coverage, is less important than the other three, and refers to the fact that the operator actions necessary to implement timed transfers may include route changes.

In general, simple timed transfers and line-ups do not produce large ridership gains, since the typically long headways on the originating leg remain an important determinant of ridership. However, some properties using pulse scheduling have experienced substantial increases in ridership. It should be noted that many of these properties instituted other service improvements simultaneously with the pulse scheduling.

In Brockton, for example, ridership increased sixfold at a time when VMT was increased four- to fivefold. However, since only 25 percent of passengers now transfer, and the reliability of service has drastically improved, the increase in ridership directly attributable to pulse scheduling may only be on the order of 10 percent of current ridership. This estimate is substantiated by the experience of Superior, Wisconsin, where ridership rose to 10 to 12 percent with the advent of pulse scheduling and no other major changes in service.

The greatest increase in ridership due to pulse scheduling will occur on systems that have a high degree of schedule reliability, and the potential for significant riding to nondowntown terminal locations because of the presence of major attractors for discretionary work and shopping trips or trips by the elderly. However, when pulse scheduling is implemented without significantly changing bus-miles and bus-hours, the absolute magnitude of the ridership effect is likely to be small. Indeed, several pulse operators (including those in Everett and Lewiston) see no definite link between pulse scheduling and ridership.

Rail Transfers

The increase in user satisfaction with bus/rail timed transfers will not be as great as with bus/bus timed transfers, due to the typically higher frequency of rapid rail lines and the longer layovers that may be required. Furthermore, the reliability of making connections is an important factor in attracting ridership, but high reliability cannot always be achieved for bus/rail timed transfers, due to the difficulty of coordinating two spatially separated vehicles that may be under the control of different dispatchers. Therefore, the ridership and revenue consequences associated with bus/rail timed transfers are likely to be positive, but not large.

Schedule Adherence on Connecting Routes: Bus and Rail Transfers

Schedule adherence on the connecting route affects the user satisfaction of transferees in three ways:

1. As the variance of transfer wait time increases, user satisfaction decreases.
2. As service unreliability increases, headways between different vehicles on the same route become unequal. Transferring (as well as nontransferring) passengers are more likely to arrive during the longer intervals, and thus experience increased mean transfer wait time.
3. As service unreliability increases, the benefits that can be realized through use of other scheduling options, particularly timed transfers and schedule coordination, are reduced.

Therefore, ridership and revenue from transferring passengers can be expected to increase as schedule adherence on the connecting route increases, though this effect may be small in comparison with nontransfer-related effects. Conversely, schedule unreliability on the originating route may produce an increase in transferring. For example, at stations where outbound commuter rail intersects feeder bus routes, rail unreliability may cause a diversion of travelers to buses who would otherwise be picked up by automobiles in the evening. This effect is a result of the reluctance of the potential auto driver to attempt to meet a train which may be indefinitely late if there is sufficiently high quality bus service. Of course, overall transit service is enhanced by improvements in schedule reliability on the originating route.

Service Frequency on Connecting Routes: Bus and Rail Transfers

The principal transfer-related effect of changing service frequency is the alteration of expected transfer wait time. As service frequency increases, expected transfer wait time will decrease, given good schedule adherence. User satisfaction rises as expected wait time decreases, particularly since transfer wait time is likely to be more onerous than other kinds of out-of-vehicle wait time. Therefore, service frequency can have a significant influence on transfer ridership and revenue as well. Ten- to fifteen-minute headways appear to be a threshold below which transfer ridership increases significantly.

3.5 Pricing Options

Transfer Charge

Bus Transfers

User satisfaction drops as the transfer charge goes up due to the inherent negative impact of extra cash expenditures. The emphasis currently placed on political/equity considerations in setting the transfer charge underscores this effect. The magnitude of the impact on user satisfaction will depend on the disutility associated with the charge (i.e., low-income versus high-income riders) and the "justifiability" of the charge (e.g., transferees take longer trips).

Different types of riders and trips will be affected differently by a change in transfer charge. Captive riders, almost by definition, have their riding patterns altered least by an increase in transfer charge. Shopping and other discretionary trips would be most discouraged. Distributor/collector transfers would probably be discouraged as well, depending upon the size of the CBD. In general, ridership should decrease because of higher transfer charges.

The ridership effects of transfer charge can be further explored through use of elasticities of demand with respect to transfer charge. Table 3-3 shows the changes in transfer rate and total ridership that result from various changes in transfer charge and basic fare. A range (-.1 to -.58) of reasonable demand elasticities with respect to total transit cost is used, since no demand elasticities with respect to transfer charge alone have ever been estimated. The "median" elasticity of -.3 used in the table corresponds to widely used rules of thumb for values of shrinkage ratios with respect to transit fare (i.e., the so-called Curtin rule).

Revenue will typically increase as the transfer charge increases. This occurs both because of the usually assumed "inelastic" demand for transit, and because of the potential for abuse (i.e., illegal resale of transfer slips) when the transfer charge is zero. Total revenue from transfer charges can amount to substantial sums. However, as a percentage of basic fare revenues, transfer revenues are usually quite small. Table 3-4 describes the revenue consequences of various transfer charge increases under different base fare and elasticity assumptions.

Table 3-3

EFFECTS OF CHANGES IN TRANSFER CHARGE ON TOTAL RIDERSHIP AND TRANSFER RATE[1]

			Low Elasticity (-.1)		Medium Elasticity (-.3)		High Elasticity (-.58)	
Initial Transfer Charge (cents)	New Transfer Charge	Base Fare	Change in Total Ridership (percent)	New Transfer Rate (percent)	Change in Total Ridership (percent)	New Transfer Rate (percent)	Change in Total Ridership (percent)	New Transfer Rate (percent)
0	5	25	-0.6	19.6	-2.0	19.0	-3.9	18.1
0	25	25	-3.3	18.4	-10.0	14.9	-19.3	9.5
5	25	25	-2.2	18.9	-6.7	16.7	-13.0	13.3
0	5	40	-0.4	19.8	-1.3	19.4	-2.4	18.8
0	10	40	-0.8	19.6	-2.5	18.8	-4.8	17.6
5	10	40	-0.4	19.8	-1.1	19.5	-2.1	19.0
5	25	40	-1.5	19.3	-4.4	17.8	-8.5	15.7

[1]Initial transfer rate assumed to be 20 percent.

Source: Charles River Associates, May 1979.

Table 3-4

EFFECTS OF CHANGES IN TRANSFER CHARGE ON TOTAL REVENUE AND TRANSFER REVENUE[1]

				Low Elasticity (-.1)		Medium Elasticity (-.3)		High Elasticity (-.58)	
Initial Transfer Charge (cents)	New Transfer Charge	Base Fare	Initial Ratio of Transfer Revenue to Total Revenue	Change in Total Revenue (percent)	New Ratio of Transfer Revenue to Total Revenue	Change in Total Revenue (percent)	New Ratio of Transfer Revenue to Total Revenue	Change in Total Revenue (percent)	New Ratio of Transfer Revenue to Total Revenue
0	5	25	0	+3.5	.038	+2.6	.037	+1.2	.035
0	25	25	0	+16.0	.155	+8.0	.130	-3.2	.087
5	25	25	.038	+12.8	.159	+7.7	.143	+0.4	.117
0	5	40	0	+1.9	.024	+1.7	.024	+0.8	.023
0	10	40	0	+4.4	.046	+3.1	.045	+1.4	.042
5	10	40	.024	+2.1	.047	+1.6	.046	+0.9	.045
5	25	40	.024	+8.4	.108	+5.5	.100	+1.6	.089

[1]Initial transfer rate assumed to be 20 percent.

Source: Charles River Associates, May 1979.

Rail Transfers

The user satisfaction consequences of a reduced bus/rail transfer charge are quite similar to those described above for bus/bus transfers. Since bus/rail transfers involve a change of mode, and tend to be part of longer trips than bus/bus transfers, riders may view them as being more justifiable. Hence, bus/rail transfer charge increases tend to decrease user satisfaction less than comparable increases in bus/bus transfer charges.

Ridership is definitely affected by bus/rail transfer charges. This is demonstrated graphically on those properties with asymmetric transfer charges for bus/rail transfers (full fare bus-to-rail, free rail-to-bus). On such properties, the number of people who transfer from rail to bus is often significantly greater than the number who transfer bus to rail. However, as for bus/bus transfers, overall revenues generally increase with a raised bus/rail transfer charge, since the ridership decline is usually not large enough to offset the increased revenue per passenger.

Use of Transfer Slips: Bus and Rail Transfers

Transfer slips have no major direct consequences on user satisfaction, ridership, or revenue. Any disutility associated with handling the slip is self-limiting, since an individual always has the option of not using it and paying full fare for the transfer.

For bus/rail transfers, the method of providing transfer slips may have a significant indirect effect on user satisfaction, ridership, and revenue due to the constraints that it places on the level of transfer charge. Washington, D.C., for instance, might offer free bus/rail transfers in both directions, were it not for the problem of handling transfer slips in the bus-to-rail direction. Therefore, riders may experience a higher total fare (and thus a lower user satisfaction) in this case as a consequence of the type of transfer slip system used.

User satisfaction may also be affected if the transfer slip procedure requires the passenger transferring from bus to rail to wait in a long change booth line instead of proceding directly through the turnstyles. Similarly, if the transfer dispensing machines malfunction, the passenger must wait to get a transfer from a clerk. In either case, the rider is faced with the choice of not getting a transfer or waiting in line, necessarily resulting in a reduction in user satisfaction.

The method of offering reduced fare transfers can affect the amount of abuse that occurs, and hence, revenue received, even after factoring out the effects of the transfer charge. Transfers issued by machine, especially in the destination rail station, tend to be more easily abused (with consequent revenue losses), because extra transfer slips can be taken. Various location strategies for the transfer machines can be tried to alleviate this problem, but it is inherent in the nature of the transfer slip system.

3.6 Information Options

Schedule Information

Bus Transfers

Schedule information at the transfer point informs the transferring passenger how long he/she will have to wait for the connecting bus, and thus raises user satisfaction by limiting uncertainty concerning wait time, and freeing the transferee for other activities, such as shopping.

Awareness of schedule information prior to the start of the trip will have a different effect: altering user behavior and perceptions by making him/her aware of possible alternative available transit travel options (e.g., timed transfers, through-routing, "best connecting vehicle," and so on). Ridership generally will increase only as the result of information provided prior to departure on the trip. Information supplied at the transfer point normally cannot affect whether the trip is taken.

It should be pointed out that riders on many properties have a low level of awareness of the transfer policy. It is reasonable to assume that word-of-mouth and personal experience are good sources of information for regular riders making their regular trips. However, it appears that a large number of infrequent riders or transferees could benefit substantially from formal procedures for disseminating information about the transfer policy.

Rail Transfers

The differences between the consequences of providing schedule information for rail versus bus transfers relate mainly to the fixed nature of rail facilities and higher frequency of rapid rail. Because rail tends to be fixed and obvious, and because rapid rail typically has a high service frequency, provision of rail schedule and route information (for transfers to rail) is both easier and less important than bus schedule and route information for transfers to bus. On the other hand, because it may not be immediately obvious to the rider transferring from rail where the connecting route stops, signs and directions within the facility can raise user satisfaction.

Marketing Initiatives

The user satisfaction consequences of marketing are related to the changes caused in awareness of and attitudes toward transit. Transfer-related marketing can change people's perceptions of the usefulness of transfers by promoting aspects of the transfer policy that make transfers easier. Marketing has been used to raise the awareness of different market segments concerning the existence of various transfer policy components, as well as coverage and services provided by the system as a whole.

Increased ridership is certainly one possible result of transfer-related marketing. For example, those systems using pulse scheduling that have experienced significant gains in ridership have marketed the distinctive features of the transfer system. Another marketable feature of the transfer system might include transferring privileges between transit systems. On the other hand, indirect applications, such as use of the transfer slip as an all-day pass, may also be productive. It is unclear which market segments are most likely to change their riding behavior as a result of transfer-related marketing efforts, but groups for whom transfers are onerous (i.e., the elderly and shoppers) seem likely candidates.

The revenue effects of transfer-related marketing include the following:

- Revenue effects of additional ridership; and
- Revenue effects if promotion includes reduced fare.

In the first case, total revenue clearly increases. In the second case, total revenue can increase or decrease. Several properties have increased their net revenue through reduced fare transfer-related promotions, not even counting the long-term effects of increasing people's awareness of and experience with transit and transfer systems.

Chapter 4
COST CONSEQUENCES OF ALTERNATIVE TRANSFER POLICIES

4.1 Introduction

Each transfer policy component described in Chapter 2 involves operator actions that may have important cost consequences. Operator costs relevant to evaluating alternative transfer policy components include the following:

- Vehicle operating costs, total and per unit (e.g., cost per vehicle mile);
- Other variable operating costs (e.g., printing transfer slips);
- Fixed administrative/overhead costs (e.g., security, accounting for transfer slips); and
- Service planning costs.

Capital costs also are relevant to some options, but are not treated in detail in this report since fixed facilities associated with transfers were excluded from this study.

This chapter outlines the cost consequences of implementing each of the 11 transfer policy options (described previously) in typical situations. In general, the cost consequences of bus/bus transfer policy options are treated first, with any differences in consequences associated with bus/rail and rail/rail transfers treated in a separate section.

4.2 Routing Options

Distance Between Routes at Transfer Points

Bus Transfers

The principal costs associated with changing the distance between routes at transfer points are due to changes in vehicle miles and vehicle hours of operation. These changes are not necessarily proportional to the change in transfer distance alone because of possible alterations in turnaround procedure, or the existence of one-way streets and other obstacles. In fact, some street patterns may render it prohibitively expensive or even impossible to reduce transfer distance.

However, assuming operating costs are proportional to changes in transfer distance, a general estimate can be made of the cost consequences of this option. For example, if two bus routes with 30 runs per day per route terminate 1,000 feet apart at the transfer point, the cost of reducing the transfer distance to zero will typically be $5,000-10,000 per year. (30 runs/day x 2,000 feet/run x 300 days/year ÷ 10 miles/hour ÷ 5,280 feet/mile x 20 dollars/hour = $6,818.)

Other strategies to reduce spatial separation may have additional cost consequences. An off-street transfer facility or transit mall may involve significant capital investment. For example, an off-street transfer facility in Brockton, Massachusetts, for 15-20 buses cost approximately $600,000 in 1978. The use of subfoci may incur additional operating costs due to overlap of routes in the CBD.

Rail Transfers

The costs of reducing bus/rail and rail/rail transfer distances are generally much greater than the costs of reducing bus/bus transfer distances due to the fixed facilities typically involved. While precise cost estimates depend heavily on site-specific factors and are beyond the scope of this report, it is possible to make two general observations:

1. It is much more costly to retrofit an existing facility to incorporate a transfer distance reduction strategy than to incorporate the strategy into the original design. This is due to both structural/design problems that may be encountered in retrofitting, and the potential unavailability of necessary land (e.g., for bus ramps).
2. Given that transfer distance-reduction strategies are incorporated in the original rail station design, their cost is likely to be quite small compared with the total cost of the facility.

Through-Routing

Bus Transfers

The most important cost consequences of through-routing are caused by eliminating turnaround time and distance at the transfer point. For instance, the elimination of certain downtown turnarounds in Portland, Maine saved approximately $15,000 (1976) per year. More generally, it is estimated that through-routing two coterminous routes on the same headway (making 30 trips daily) will typically save $12,000-25,000 in annual operating costs, of course depending on bus operating costs, average bus speeds, length of turnaround eliminated, and so on (e.g., 30 runs/day x 1.2 miles/run ÷ 10 miles/hour x 20 dollars/hour x 300 days/year = $21,600/year).

Other cost-related consequences of through-routing that may also be significant include the following:

- Headway Adjustments: If adjustments are needed to match headways, their cost impact (either positive or negative) may be large in comparison with the benefits of eliminating turnaround.
- Logical Scheduling: Costs can often be reduced by combining routes because route run time (including layovers) on a single route does not have to be evenly divisible by the headway. This facilitates "clock face" scheduling.
- Reliability: Service reliability may increase, decrease, or remain unchanged with the institution of through-routing, depending upon the schedule adherence characteristics of the original routes that are paired, the ability of the transfer point layovers to absorb schedule disruptions, and the changes in layovers that are made on the new paired route. Given a pair of routes, overall reliability on one with through-routing will be better if one route had excess layover time, will be worse if one route was chronically late, and will be the same if both routes had adequate layovers that are not eliminated when the through-routing is implemented.
- Scheduling Effort: Options such as variable through-routing and trippers may require a significant effort on the part of service planners (though several versions of RUCUS naturally yield extensive interlining).
- Enroute VMT and VHT: If paired routes do not coterminate, or if an overlap-type strategy is used, the institution of through-routing may have significant adverse effects on bus operating costs that must be traded off against user satisfaction/revenue increases, and possible sources of cost savings.

Rail Transfers

Bus route consolidation can greatly reduce bus operating costs by reducing bus miles and hours, particularly in congested areas near or in the CBD. Turnaround is not eliminated, but it is moved out of the congested CBD, thus providing a further cut in VHT. Bus route consolidation therefore can result in major cost savings.

4.3 Scheduling Options

Schedule Coordination

Bus Transfers

The cost consequences of schedule coordination result primarily from headway adjustments and scheduling effort. Historically these cost effects have been minor, perhaps due to the reluctance of operators to use schedule coordination if extensive frequency changes are needed. CBD schedule coordination may involve some headway matching on several consecutive runs, but changes are not significant in the context of normal peak-hour headways. Some extra scheduling effort is involved. Trunk-crosstown coordination will also require some scheduling effort, and headway adjustments may be significant if all crosstown runs are scheduled to meet trunk line runs. If only a few runs are adjusted after schedules have been prepared, cost consequences will be quite small. Minor schedule coordination has almost no cost consequences, since it typically involves only slight schedule adjustments on a single run.

Rail Transfers

There are three types of schedule coordination involving rail, each with its own cost consequences:

- Rail-to-Bus Coordination: The costs of rail-to-bus coordination are quite similar to those of trunk-crosstown coordination. Administrative cost and effort may be somewhat greater because bus and rail schedule makers often work independently.
- Bus/Commuter Rail Coordination: For bus/commuter rail coordination, both operating and administrative costs are greater than for rail-to-bus coordination. Administrative costs are greater because bus and rail schedule makers are usually in different operating authorities, and because buses must meet particular trains. Operating costs are greater because this option generally requires a special bus run devoted to meeting the commuter train. This will increase costs, but since commuter train arrivals and departures in outlying towns often fall outside of the peak hour for trips within the town, providing bus connections does not necessarily increase the total number of buses needed in service and can be less costly than adding peak-hour runs.
- Rail/Rail Coordination: The cost consequences of rail/rail schedule coordination appear to be small, since rail systems typically operate on longer headways in the evening, when this option is most often employed.

Dynamic Control of Departure Times at Transfer Points

Bus Transfers

The costs of dynamic control arise from the following sources:

- Capital costs of communications system;
- Extra layover time needed to compensate for schedule perturbations; and

- Excessive use of dynamic control, overloading the radio system, and requiring significant dispatcher and driver time and attention.

Overall, the magnitudes of these costs are small. Generally, if a bus is held for a few minutes, it can make up the time without requiring additional layovers. Unless this option is implemented and publicized on a widespread basis, its utilization should not require excessive time and attention. Capital costs of communications equipment may be significant, but are often offset by nontransfer-related benefits.

Rail Transfers

Dynamic control applied to the bus side of rail/bus transfers also tends to have minor cost consequences, except in situations where rail service is extremely unreliable and/or there are poor communications between bus and rail. The costs of dynamic control again arise principally from additional layover time and from the cost of whatever signaling equipment is needed. Most rail properties do not incorporate much additional layover time into the schedule, since the hold time (except in the case of formal meetings) is generally short. The capital and maintenance costs of train arrival signals are low, particularly if use of dynamic control is restricted to a limited number of stations.

Timed Transfers

Bus Transfers

It is possible for the implementation of timed transfers to have only minor impacts. Even pulse scheduling, the most extensive form of timed transfers, has been implemented virtually without cost on some transit systems. However, this "costlessness" does not apply to all systems using timed transfers. Potential sources of cost impacts include the following:

- Frequency changes;
- Extra layovers;
- Scheduling effort; and
- Cost for space.

The changes in bus-hours and bus-miles that result from creating uniform headways on different routes have the greatest potential influence on cost. Frequencies may be increased or decreased (or both) on any particular property to produce compatibility.

The extra layover time needed to ensure schedule reliability and transfer connections may also affect costs. As extra layovers are built into the system, total operating costs may increase if VMT are preserved, or decreased due to savings in mileage-related costs (if no more buses are added).

Costs may also be affected by the scheduling effort needed to establish timed transfers, or the costs of the stopping space required by all of the pulsing buses. The latter cost is not normally a direct financial burden on the operator, since buses typically utilize city streets for stops. However, it may produce losses in parking revenue for the municipal authority and cause increases in traffic congestion as well as possible aesthetic problems.

The different variants of timed transfers tend to have distinct cost consequences:

- Simple Timed Transfers: Typically involve minor frequency changes and little scheduling effort (especially if policy headways are used), little need for extra layovers, and no space problems.
- Pulse Scheduling: Potentially significant cost consequences due to frequency changes, moderate scheduling effort; may require extra layovers; often encounters space problems.

- **Line-ups**: Minor frequency changes possible; some scheduling effort required; little need for extra layovers due to generally high schedule reliability in evenings when this option is used; some space problems.
- **Neighborhood Pulse**: Same as pulse scheduling.

Rail Transfers

Bus/rail timed transfers are generally much more costly and disruptive than bus/bus timed transfers due to the longer layover required to guarantee a reliable connection. This is because the spatial separation for bus/rail transfers is typically greater than that for bus/bus transfers, necessitating more time for the vehicles to exchange passengers. This option is therefore least costly when used at outlying rapid or commuter rail stations, or when across-platform transfers are feasible.

Schedule Adherence on Connecting Routes

Assessment of the costs and other consequences of various remedial strategies for schedule unreliability are generally beyond the scope of this report.[1] It is clear that strategies such as insertion of standby vehicles lead to the largest increase in costs, while skip-stopping and first-vehicle passing involve little or no additional cost.

Service Frequency on Connecting Routes

The cost of increasing service frequency is quite substantial. Operating costs will generally increase in

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[1]See Mark Abkowitz, Howard Slavin, Robert Waksman, Larry Englisher, and Nigel Wilson, Transit Service Reliability, Transportation Systems Center, U.S. Department of Transportation, December 1978, for a detailed assessment of alternative strategies.

proportion to VHT and VMT, and vehicles may not be available to raise service frequency without capital expenditures. These costs are large in comparison with transfer-related benefits. Therefore, significant changes in service frequency are typically made in response to nontransfer-related factors such as overall demand, rather than simply transfer demand (for example).

4.4 Pricing Options

Transfer Charge

Bus Transfers

The two types of cost consequences that can be associated with the transfer charge are possible slowdowns in bus passenger entrance resulting in longer route run times, and the marginal effort required to count and process additional revenue. When reduced fare transfer charges are offered, there will also be some costs associated with the administration method (usually transfer slips). These latter costs are addressed in the following section.

The cost of slowing down the bus to process the transfer charge may sometimes be significant. A small but nonzero transfer charge probably slows down buses the most, since it involves the exchange of both money and some type of validation (e.g., transfer slip). Passenger uncertainty or disputes concerning the exact level of the charge may also increase run times. A full transfer charge slows down buses the least since no special procedures or privileges are involved. A zero transfer charge can be assumed to have an intermediate effect. Overall, the effects of the transfer charge on the passenger processing times are relatively small, though they are believed by operators to be much more important than marginal changes in the level of effort required to process additional revenues.

Rail Transfers

The cost consequences that result from having a particular bus/rail transfer charge are due almost entirely to the administrative method used, and will thus be treated in the following section. Processing revenues from the transfer charge itself is not a cause of significant cost consequences.

Use of Transfer Slips

Bus Transfers

Possible sources of transfer slip costs include:

- Transfer slip printing;
- Personnel needed to administer and issue transfers; and
- Driver time at end of shift to account for transfers.

The last item is potentially very significant, depending upon the emphasis placed on keeping close control over transfer slips (most important for nonzero reduced fare transfers, which create incentives for driver fraud unless transfer slips are carefully accounted for). Overall, the use of transfer slips does not have major cost consequences, though estimates of up to $1 million annually have been made on large bus systems.

Rail Transfers

Methods for providing bus/rail transfers generally have quite significant cost consequences. The principal cost consequences of bus/rail transfers in most cities arise from the need to add gatemen and change clerks in rail stations to issue and collect transfers. A 1976 Boston study estimated the total additional labor cost of bus/rail transfers to be $1,950,000 (including bus driver time accounting for the transfers). Transfer-dispensing machines may reduce labor costs considerably, but have significant capital and maintenance costs of their own. Other costs include the cost of the transfer slips themselves (estimated to be $225,000 per year in the Boston study, and one cent per magnetic card in Atlanta, for a yearly total of $15,000), and the extra cost of station construction when a paid area is included.

4.5 Information Options

Schedule Information

The costs of providing schedule information are both direct and indirect. The direct costs include printing schedules, manning phone banks, drawing and printing maps, installing and maintaining display facilities, etc. The indirect costs are subtle, and can be thought of as a type of opportunity cost: when an operator has publicly stated a transfer policy, it is often difficult to change it even when it becomes unproductive. Whether or not this is true in all cases, it is clear that indirect costs of this type must be considered.

Marketing Initiatives

A detailed examination of the costs of transfer-related marketing is beyond the scope of this guideline document. In general, transfer-related marketing is low-cost. Many radially oriented transfer systems, for instance, have many fewer transfer points than bus routes, making it simple to promote and explain the transfer system. On the other hand, it is possible to spend significant amounts on transfer-related marketing, especially when it is not mounted as part of a wider marketing effort.

Chapter 5
TRANSFER POLICY DESIGN

5.1 Introduction

In this chapter, the tradeoffs among the costs and benefits of implementing each transfer policy component are outlined. Potential problems and constraints associated with applying the component in different situations are identified, and settings in which the component might effectively be utilized are suggested.

5.2 Routing Options

Distance Between Routes at Transfer Points

When considering a reduction in route separation at a transfer point, the key tradeoffs involve costs and user benefits. Costs arise principally from changes in VMT and VHT, and sometimes from facility costs (as in bus/rail transfers). User benefits accrue because of the decrease in transfer walk distance. For passengers transferring between buses, an ideal transfer arrangement is one where the transfer walk distance is less than one or two blocks, with clear lines of sight between buses. For bus/rail and rail/rail transfers, the most desirable situation is where the transfer is across the platform, with the maximum walk being half the length of the train.

There are three major factors that determine how closely a given transfer point can approach this ideal situation. These are as follows:

- Number of vehicles meeting at transfer point;
- Size of CBD;
- Cost and availability of land and space for stop locations.

Available information suggests strongly that the upper bound on the number of buses that can be present simultaneously in the area surrounding a single bus/bus transfer point is approximately 20. Above this number, even if all buses formally meet in the same area, there will necessarily be a significant transfer walk distance and obstructed lines of sight between at least some pairs of routes. For bus/rail transfers, this number is much lower.

The size of the CBD is important because line-haul transit often serves as a downtown distributor if the CBD is large enough so that no single terminal area is within walking distance of all of it. Concentrating the termination points of all routes in one spot in such a CBD may cut down overall coverage and greatly increase transferring unless costly detours are made. Therefore, except where the layout of the CBD is well suited to single-point termination, transit systems with large CBDs cannot generally obtain the most desirable walking distance between all vehicles at a single transfer point.

The third important constraint applies mainly to bus/rail transfers, which often require special facilities (e.g., bus tunnels) to minimize transfer distance. Because of the many competing uses for land and air space around rail stations, the ideal situation described above for bus/rail transfers is rarely practical to attain. (Potential exceptions to this involve commuter rail at outlying stations, or cases where both rail and bus are at-grade in low density areas.)

Bus Transfers

It is therefore often necessary to consider alternatives to the most desirable transfer arrangement. Each of these alternatives has its own constraints and preferred application settings. For bus/bus transfers, these alternatives are the following:

- Off-street Terminal Facility: This option raises the number of buses which can meet at one point, and reduces pedestrian obstacles. However, it may be necessary to use a noncentral location, and there may be significant capital costs. This option is best implemented when there are nontransfer-related benefits as well (e.g., reduction of street congestion).
- Bus Transit Malls or Streets: With this option, the number of routes is not a constraint, and transfer walk distance is effectively very low, since vehicles from different routes pass the same points. Depending on the shape of the CBD, transit malls may reduce CBD coverage and require more walking and more transfers. This option is most feasible when the CBD is narrow (e.g., four blocks), and can often be implemented without significant capital costs.
- Subfoci: With this option, the overall number of routes is not a limitation, transfers between routes within subfoci are easy, and the CBD is well covered. Operating costs increase due to the extra VMT in the congested downtown area. These costs tend to restrict the use of subfoci in larger cities.

- <u>Grid</u>: With a grid system, the distance between routes at transfer points is minimized. Unfortunately, dispersed transfer points may be less understandable and less safe in the evening than single or multiple route foci. This option is most often employed in cities with large central areas of high density employment and population, where a grid system may be the only appropriate route structure.

<u>Rail Transfers</u>

For bus/rail transfers, the alternatives are the following:

- <u>Reduction of Perceived Vertical Distance</u>: The use of elevators, escalators, etc., makes bus/rail and rail/rail transferring easier when originating and connecting vehicles are on different levels. However, it may be extremely expensive to retrofit existing stations. This option is most cost-effective when it is included in the original construction.
- <u>Reduction of Actual Vertical Distance</u>: Through use of bus tunnels or ramps, this option reduces transfer distance, but may be prohibitively costly or physically impossible to implement in some locations.
- <u>Off-Street Bus Terminal Facilities</u>: This option can reduce horizontal separation for bus/rail transfers, but may incur significant capital costs. Indeed, it may be difficult to procure sufficient land area at many rail stations.
- <u>Vertical Alignment of Bus and Rail Routes</u>: This can be a low cost method for reducing the horizontal transfer distance between bus and grade-separated rail, if accessible and usable surface area is available. The number of bus routes that can be accommodated this way may be limited.

- Bus Ramps into Station: Horizontal distance can also be reduced by providing for across-platform transfers. This option may be prohibitively expensive or physically impossible to incorporate in an existing station, and is most cost-effective when made part of an original design.

One final important factor to consider when examining the tradeoffs involved in reducing spatial separation is that some transfer policy options, such as through-routing, schedule coordination, and timed transfers, require or are greatly facilitated by physical proximity of connecting vehicles. In these cases, the tradeoffs connected with spatial separation cannot be treated independently of the tradeoffs connected with consideration of the other options. Thus, while reducing spatial separation has its costs, it may also have benefits which go beyond those of the single transfer policy component standing alone.

Through-Routing

Bus Transfers

Bus through-routing can be used for two distinctly different reasons: operations and ridership. Both types of through-routing are considered in detail below.

Through-Routing for Operations -- Through-routing can produce significant cost savings through elimination of turnaround time and distance, opportunities for logical scheduling, and potential gains in service reliability. While headway matching may add costs, and extra scheduling effort may be needed, the net effect of through-routing is generally to reduce costs.

Substantial cost savings are most likely to occur in cities with a congested CBD where routes enter from more than one direction. Through-routing is most applicable as an aid to logical scheduling when properties are constrained by service area boundaries, or when operators seek to maintain clockface or pulse scheduling. The presence of clockface or pulse scheduling will also tend to minimize the need for further headway matching to implement through-routing avoiding potentially adverse cost impacts.

It cannot be emphasized too strongly that the operational and cost consequences of through-routing are heavily dependent on the street layout and other conditions. For instance, on some properties the dominant reason for implementing through-routing might be the elimination of dangerous left turns. On other properties the relevant operational/cost considerations might be equally site-specific.

Through-Routing for Ridership -- Through-routing eliminates transfers, thus eliminating waiting and walking time and producing significant benefits for riders. Through-routing for ridership is often profitably employed where there is a high volume of transferring passengers between two routes with a common terminus. Properties with strong and definite flows to outlying shopping malls, for instance, may want to interline the mall route with a route running through a densely populated residential area. The groups tending to benefit from this would be shoppers and the elderly, the groups whose user satisfaction is most increased by through-routing. Properties with periodic peak flows to particular points, on the other hand, might profitably run trippers. If there is a relatively dispersed flow of transferring passengers, variable through-routing is a possible option. This will principally benefit the elderly, or others who are made aware of and can afford to wait until a particular time of day for service. Properties that have a large amount of transferring to reach destinations within the CBD may consider overlap.

Conclusions -- Through-routing for ridership is not necessarily incompatible with through-routing for operational reasons. Passengers transferring between two routes, though, may be only a small portion of the total ridership on the routes. Hence, route pairings for maximum user satisfaction may not be the same as route pairings for maximum cost and operations benefit.

Another important consideration is whether to publicize through-routes. Properties which through-route for operational reasons may not wish to advise passengers formally of the connections, thus making future switches in route pairings easier to execute. However, ridership benefits in the short run may be minor, since information must be spread by word-of-mouth and personal contact, and infrequent users may never become aware of the service.

If through-routing is publicized, user satisfaction may be increased. However, this publicity will tend to restrict future changes in route pairs. If future adjustments are made, lower user satisfaction and public relations problems could materialize.

Rail Transfers

The tradeoff involved in route consolidation is simpler than the ones described above for bus through-routing, and weighs the cost of providing parallel service against the decrease in user satisfaction caused by forcing people to transfer and by eliminating local service between rail stops. Route consolidation is most productive when the CBD and the corridor leading into the CBD are so congested that bus speeds are slow and trip times are long. In this case, a low-frequency, low-cost local route can handle passengers who are traveling for short distances between rail stations.

The tradeoff between cost and user satisfaction is significant: a) if the rail line has such a low frequency that lengthy transfer times are possible when transferring from bus to rail; b) if the rail line is unreliable or unattractive; or c) if the rail line is short. Under these conditions, route consolidation may significantly lower user satisfaction.

5.3 Scheduling Options

Schedule Coordination

Bus Transfers

If transfers are strongly directional between two lines at any time of the day, and if a reasonable degree of schedule reliability exists, schedule coordination may be a very productive action for the operator to undertake. It typically costs little, can involve only minor headway changes, and demands almost no real-time operator attention. Because user satisfaction for the (assumed) large proportion of people transferring in the correct direction is increased as their average transfer time is decreased, ridership will be induced in most cases. Schedule coordination therefore may be a very cost-effective way to improve service.

However, there are definite limitations on the opportunities for application of most types of schedule coordination. The major restriction is the need for strong directionality of transfers. People transferring in the "wrong" direction will have a transfer wait equal to the entire headway (minus the advance) of their connecting bus. From the point of view of ridership, equity and public relations, this may be unacceptable if a sizable number of people are affected.

The result is that schedule coordination is inapplicable in many situations. For instance, it is largely inappropriate for off-peak usage, since shopping traffic is inherently two-way. More importantly, it cannot be used in the CBD unless there is a skewed distribution of origins and destinations by time of day. Since this is a condition which is much more likely to occur in small cities than large ones, city size is a determinant of the applicability of schedule coordination.

Each of the three types of schedule coordination is discussed below.

- CBD Schedule Coordination: This option can improve level of service for transferring passengers, though it requires some scheduling effort, and sometimes changes in headways. CBD schedule coordination can profitably be used in cases where a definite peak directional flow of passengers from one area of a city to another passes through the CBD.
- Trunk-Crosstown Coordination: This option generally costs little, and has minor negative effects on people transferring in the opposite direction. Trunk-crosstown coordination is more widely applicable than CBD schedule coordination, since the typically high frequency of trunk lines makes its effects less sensitive to the directionality of the transfer flow.
- Minor Schedule Coordination: This option is easy to implement, though it typically does not lead to large ridership gains. It can be implemented on any transit system, even the largest and most complex, at any time of the day.

Rail Transfers

There are three types of schedule coordination involving rail vehicles. These are the following:

- Rail Transit to Bus Coordination: This option reduces transfer time for passengers transferring to bus. It is most appropriate in the evening at outlying transfer points, where the frequency of the connecting bus line is relatively low and the rail transit lines are fairly reliable.

- Bus/Commuter Rail Coordination: This option is most productive when buses can be "dedicated" to serving commuter rail. In this way, the disruptions caused by unreliable rail service are minimized.
- Rail Transit/Rail Transit: This option provides short transfer times for some riders, but its use is limited by the spatial separation between rail routes. This option is most applicable in the evening at transfer points where rail lines are on relatively long headways, transfer flows are directional, and rail lines are not too widely separated.

Dynamic Control of Departure Times at Transfer Points

Bus Transfers

By definition, dynamic control perturbs the schedule. On a simple system this disturbance may not have widespread effects. On a more complex network of routes, use of extensive dynamic control may produce harmful schedule disruptions. There is also a limit on the number of dynamic control "messages" that a radio system can handle. The major constraints on the use of dynamic control thus tend to be the size and complexity of the system.

This does not mean that larger properties cannot use dynamic control. It does mean, however, that it should be used sparingly, and substituted for as appropriate, particularly on larger properties. For example, if dynamic control is used regularly at a particular transfer point, then an option such as schedule coordination might be more appropriate than a regular real-time adjustment in operations.

There are many situations where dynamic control is a low-cost method for obtaining large gains in user satisfaction for some riders, and for improving overall public relations.

Dynamic control is applicable whenever two low-frequency routes intersect, and it is productive to guarantee that transferring passengers will make their bus. Dynamic control is also applicable in cases where a low-frequency route receives a significant volume of transferring passengers from a higher-frequency route. By holding the vehicle on the low-frequency route to ensure that it meets an approaching vehicle on the other route, wait time is reduced.

More generally, dynamic control, as a separate option, is appropriate either when transfer flows are intermittent, or when schedule unreliability is common. In the first case, dynamic control provides a way of making adjustments in operations only when they are needed to accommodate transferring passengers, and is thus a substitute for schedule coordination. In the second case, dynamic control can cause buses which would not have met otherwise to meet, thus mitigating the effects of schedule unreliability on transferring passengers.

An important application of dynamic control is on timed transfer properties, where a guarantee that buses will meet is necessary to attract new riders and ensure the satisfaction of old riders. Dynamic control with timed transfers may require some additional layover time, although not as much as if layovers alone were used to overcome reliability problems. On both cost and user satisfaction grounds, dynamic control is generally a workable compromise between no alleviation of schedule uncertainty, and the addition of layover time sufficient to absorb all schedule variance.

Rail Transfers

The same tradeoffs, constraints, and applicability criteria as described above for bus/bus dynamic control generally hold for dynamic control of bus/rail and rail/rail transfers as well. In addition, dynamic control may be worthwhile in cases where schedule coordination would be useful but is difficult to implement (e.g., rail/bus transfers where the two modes are scheduled independently). It should be noted that dynamic control of bus/rail transfers can typically only be used in the rail-to-bus direction, because of the problems introduced by real-time perturbations in the rail schedule.

Timed Transfers

Bus Transfers

There are three key elements which help determine whether some form of timed transfers should be implemented on a particular transit system. The first of these is reliability. The importance of high reliability of making connections on user satisfaction must be weighed against the costs of ensuring that level of reliability. These costs are due to the possible need for added schedule layover and/or dynamic control. Hence, cities with severe schedule adherence problems might tend to find increasing user satisfaction via timed transfers to be prohibitively expensive.

Existing service frequency also influences the applicability of timed transfers. At high enough frequencies (e.g., 15-minute headways) the drop in average transfer time attributable to timed transfers is relatively minor, and not worth the effort of establishing a timed transfer system. On the other hand, low frequencies on originating routes limit the amount of ridership which timed transfers can attract. If service frequencies are low, timed transfers alone will not produce major ridership effects.

Space limitations on the number of buses which can meet have an important influence on the applicability of timed transfers. Twelve buses at a time is average for pulse scheduling, with neighborhood pulse having somewhat fewer and line-ups having somewhat more. Moreover, even if there is a place to meet, the distance between buses will exert a very significant effect on the transfer time.

The advantages, disadvantages, and range of settings for each type of timed transfer are presented below.

- Simple Timed Transfer: Because they only involve two routes, simple timed transfers are not constrained by space limitations. Likewise, headway and reliability problems are easily soluble. However, simple timed transfers will not increase overall system ridership significantly. This option can be used on any system, though it is more likely to be found in medium size cities, since small properties do not usually have significant outlying transfer points, and large properties have more complex systems in which the scheduling of several simple timed transfers may not seem worth the effort.
- Pulse Scheduling: Pulse scheduling can have a significant positive impact on overall ridership, revenues, and systems comprehensibility. To obtain these benefits, however, added layover and/or dynamic control may be needed to increase service reliability, frequency changes may be required, and space limitations must be overcome. This option is typically used by transit properties with less than 400,000 people in the service area, because: a) larger properties may have more chronic schedule reliability problems; b) larger properties tend to have higher and more diverse frequencies across routes, making scheduling changes at the same time more difficult and less productive; and c) larger properties would often have more than 12 buses arriving simultaneously during peak and base periods, making it difficult to find a place where all buses could meet. Other factors influencing the applicability of pulse scheduling are the dispersion of

origins and destinations, geographic layout (having the CBD in the center of the service area) and, most importantly, having a political climate in which transit innovation can occur.

- <u>Line-ups</u>: Since line-ups are utilized on larger properties in the evening and off-peak only, schedule reliability is not such a great problem. Policy headways of 30 minutes or an hour may already be in effect, and space limitations are less of a constraint. Overall, line-ups are easier to schedule and operate than pulse scheduling. While increases in user satisfaction or ridership tend to be minor, this option may produce some benefits for properties with large service area populations (e.g., greater than 400,000) for which full-scale, all-day pulse scheduling is infeasible.
- <u>Neighborhood Pulse</u>: In general, this option is easy to schedule and implement because only a few routes are typically involved. However, unless trunk routes are incorporated, this option can only improve travel within a particular neighborhood, or around a regional subcenter which serves as a logical pulse point.

<u>Rail Transfers</u>

Many of the issues surrounding the use of timed transfers for buses apply to bus/rail timed transfers as well. For example, to guarantee the reliability of transfers without excessively costly layovers, dynamic control of the vehicles making the timed transfer is often implemented. In addition, spatial separation must be reduced. Having buses which are dedicated to meeting the trains will also improve reliability, thus increasing ridership. It must be emphasized, however, that bus/rail and rail/rail timed transfers are rare compared to bus/bus timed transfers.

Schedule Adherence on Connecting Routes

The direct transfer-related benefits of improving service reliability (reduction of transfer wait time and transfer wait time variance) are almost always dwarfed by the nontransfer-related benefits of increased reliability. Therefore, the direct transfer-related benefits of improving schedule reliability will be comparatively less important in the decision to implement reliability control strategies.

Nevertheless, there can be significant indirect transfer-related benefits associated with an improvement in service reliability. In a simple timed transfer, for example, if the originating bus is late, then the timed transfer will not be made without costly and disruptive holding of the connective bus, or the incorporation of extra layover time. Thus, adequate service reliability is a prerequisite for simple timed transfers.

In addition, there are many other transfer options which depend on some minimum level of schedule adherence to maximize their user satisfaction impacts and minimize their cost impacts. For instance, pulse scheduling can only attract ridership if the transferring passenger can be assured of making his connection. Under dynamic control a bus can wait only about five minutes before the strategy becomes infeasible due to operational perturbations and the costs of extra layovers. Schedule coordination and other forms of timed transfers as well depend on basic service reliability for their effectiveness.

Schedule unreliability is thus a major constraint on the transfer components that can be utilized in a transit system's overall transfer policy. If unreliability is too high, many other operator actions regarding transfers are likely to meet with limited success. Since the consequences of options such as schedule coordination and pulse scheduling can be quite large, minimizing unreliability for the purpose of implementing transfer policy components may produce significant transfer-related benefits.

Service Frequency on Connecting Routes

Changing service frequency on a route will usually have consequences for overall ridership and user satisfaction which dominate the transfer-related consequences. While implementation of some transfer policy options (e.g., pulse scheduling) may entail minor frequency adjustments, the tradeoff between the costs of increasing service frequency and its benefits is usually determined by nontransfer factors.

Existing service frequency does have a major effect on determining the applicability of other transfer options. The key concept in this determination is "effective service frequency." Effective service frequency is defined from the point of view of a transferring passenger traveling to a specific destination. Its components are the number of routes traveling over the link to the desired destination, their scheduled headway, and the amount of headway variability that exists. Effective service frequency measures the amount of time a passenger can expect to wait before the arrival of a bus that he can utilize. For instance, in the case of collector/distributor transfers in the CBD, effective service frequency may be quite high because many routes use the same streets.

An effective headway of 10 to 15 minutes is widely regarded as a threshold, below which no other transfer scheduling options are generally needed. It is important to emphasize that effective service frequency is the key, and not nominal schedule frequency on one particular route.

The existence of such a threshold is quite plausible. No transfer scheduling option, including pulse scheduling, can consistently guarantee a transfer wait time (not necessarily out-of-vehicle) of less than five minutes, because layovers must be that long to ensure that transferring passengers make connections. Hence, application of scheduling options to a route with a ten-minute headway cannot significantly decrease expected transfer wait time. Since user satisfaction cannot be increased significantly, service frequencies on connecting routes of under ten minutes generally render other transfer scheduling options unproductive.

This relationship between service frequency and the applicability of other transfer policy components tend to explain why scheduling options are often not applied to rapid rail lines. Rapid rail typically has high service frequencies through most of the day that fall below the 10-15 minute threshold. Hence, it is usually not worthwhile to adjust the schedules of rapid rail lines for transfer purposes.

5.4 Pricing Options

Transfer Charge

Bus Transfers

Each of the three levels of transfer charge -- zero, small but nonzero, and full -- are stable and viable. There is no transfer charge which is uniformly "superior" in all situations. It is therefore necessary to consider tradeoffs when setting the transfer charge. The principal features which may be considered include:

- Equity;
- Ridership;
- Revenue;

- Abuse; and
- Nuisance to passengers.

A zero transfer charge may minimize equity problems and will maximize ridership, but produce the lowest possible revenue, and tend to lead to abuses (e.g., illegal resale of transfer slips.) A small but nonzero charge will tend to eliminate abuses and produce more revenue, though equity issues may be raised unless the transfer charge is used as a proxy for a zonal fare system or is otherwise "justifiable." A small but nonzero transfer charge may also have some nuisance value to passengers, who do not perceive the benefit received by the operator from a $.05 or $.10 payment to be worth the effort to collect it. Full fare transfers are the simplest, produce maximum revenue, and result in no abuse. However, they minimize ridership and may maximize political/equity problems.

An example helps to illustrate typically important tradeoffs. Consider a property which has a zero transfer charge, and a large proportion of "captive" transferees. If equity were not a constraint, this property could increase revenue and reduce transfer slip abuse by raising the transfer charge. The prevailing low transfer charge maximizes ridership, and yields the fewest political/equity problems.

Clearly, operator goals and policies play a major role in determining the best transfer charge in a particular setting. For example, maintaining a low base fare to encourage total ridership may call for relatively high transfer charges for revenue reasons. A large deficit may also necessitate raising transfer charges to raise more revenue. Of course, transferring and overall ridership may be discouraged by a high transfer charge. Furthermore, it seems unlikely that a full transfer charge could be imposed on a system which currently has a high transfer rate without substantial political/equity problems. Obviously, there are many factors related to operator goals and policies which enter into the selection of the appropriate transfer charge.

Rail Transfers

The factors which must be balanced in setting the transfer charge are basically the same in the bus/bus and bus/rail cases. However, there are some considerations that might cause the importance of different factors to vary when rail is the connecting mode. For example, a bus/rail transfer system is typically more susceptible to large-scale abuse than bus/bus transfers because of the lack of personal contact in transfer slip distribution. Therefore, both the revenue consequences of abuse and the costs of reducing the abuse can be greater as well. Hence, the potential for abuse is more important in deciding the level of bus/rail transfer charge than the level of bus/bus transfer charge.

The bus/rail transfer charge is also typically subjected to downward pressure because of such factors as political considerations. On the other hand, if bus/rail transferees have higher incomes than other transferees, they will tend to be less sensitive to transfer charge increases, producing significant amounts of revenue. As in the case of bus/bus transfers, the selection of the transfer charge depends heavily on the goals of the operator.

Use of Transfer Slips

Bus Transfers

There are three major methods of offering reduced fare for bus/bus transfers: transfer slips, daily (or longer term) passes, and transfers without transfer slips. The first two alternatives are very common. The third alternative is relatively rare, but can be used when a small number of buses meet on a pulse schedule (e.g., Haverhill, Massachusetts), or when there is a restricted-access facility (e.g., terminal) at the single transfer point on a system.

There are many cities, however, in which all transferring occurs at one location in the CBD. A restricted-access, off-street terminal facility would allow reduced fare transfers without transfer slips and their associated costs. In addition, a facility for bus/bus transfers would have significant positive transfer-related effects (e.g., shelter, security, reduction of spatial separation, and pedestrian obstacles) over and above the elimination of transfer slips and transfer abuse. Of course, such a facility might require a major capital expenditure, and would not generally be warranted solely on the basis of its transfer-related benefits.

In most situations, the considerations involved in setting the level of bus/bus transfer charge dominate those associated with picking a method of granting reduced fare transfers. Overall, transfer slips are the preferred method for granting bus/bus transfers.

Rail Transfers

There are many methods available for offering reduced fare bus/rail transfers. Unfortunately, most of these methods are subject to abuse of some sort, especially when the dispensing of the transfer slips is done by machine. In addition, if bus/bus transfer slips are not already used, a rail/bus transfer slip may incur significant administrative costs. Bus-to-rail transfers may require added labor in the rail stations, or automatic fare collection equipment to dispense transfers in the buses. A simple, low-cost method of offering bus/rail transfers is the one which is commonly used for rail/rail transfers; that is, have no barrier transfers where both vehicles are in the same paid area. This option would entail no operating costs, but is usually only practical if implemented at the time the station is built. Overall, there is no single preferred method for offering bus/rail transfers.

5.5 Information Options

Schedule Information

If the schedule and routes of a transit system never changed, provision of schedule information of all types would clearly be the preferred action. The direct costs of providing schedule information are not high (except perhaps in the case of a large telephone-based information system), and positive user satisfaction and ridership benefits would result. In particular, riders could be informed about all user benefits accruing from the transfer policy without fear on the part of the operator of future constraints.

However, it is when change occurs on a regular basis on the transit system (as it typically does), that the decision to provide schedule information needs to be examined more carefully. Increases or decreases in demand, available funds, available vehicles, labor supply, etc., can all produce the need to change schedules. The key tradeoff is between the benefits of providing current schedule information, and the cost of either changing the information in response to changes in the system, or not changing the system (because of the already disseminated information) and tolerating the resulting inefficiencies.

This tradeoff may be considered separately for each aspect of the transfer system which might be publicized. Route structure, for instance, is usually more stable than the schedule (particularly for rail), so listing transfer points in a schedule poses fewer potential problems than listing the schedules of connecting routes. Also, the "best connecting vehicle" may change as the result of a small change in schedule. Therefore, few properties put "best connecting vehicle" information in their printed schedules. Each component of the transfer policy may or may not be ruled out by the need to make periodic adjustments in schedules and routes on any particular property.

Marketing Initiatives

When considering transfer-related marketing initiatives, the cost and administrative effort must be traded off against a variety of potential benefits. If the transfer aspect is part of a larger marketing effort, these costs may be very low. Significant benefits may be realized if the transfer system has distinctive features such as pulse scheduling, transit malls, transfer slips which entitle the holder to other privileges besides transfers, or transfers which are good on more than one carrier. Anything out of the ordinary about the transfer system may provide a good focus for the marketing campaign if it improves the typical level of service, is discrete and easy to explain, and does not provide an opportunity for overuse which would be detrimental to the system.

Any particularly onerous feature of the transfer system may also justify a marketing effort. For instance, when transferring passengers must walk a significant distance to transfer, marketing can lessen their uncertainty about where to go, or about the environment, and highlight productive opportunities which exist on such a walk. In such cases, marketing may also have positive effects beyond mitigating the onerous aspects of the transfer.

Summary

A summary of transfer policy options and their effects is presented in Table 5-1. The interested reader is referred to the companion report, State of the Art of Current Practices for Transit Transfers,[1] for further, in-depth analysis of transfer policy options and their effects.

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[1]Charles River Associates, op. cit.

Table 5-1

SUMMARY OF STUDY FINDINGS

Option	Operator Effort	Cost	User Satisfaction	Ridership	Revenue
DISTANCE BETWEEN ROUTES AT TRANSFER POINTS					
Bus					
Central On-Street Transfer Area	o	o	■	■	■
Off-Street Transfer Facility	x	x	x	■	■
Transit Mall	■	■	x	■	■
Sub-Foci (bring routes together outside central area)	o	o	■	■	■
Grid	■	o	■	■	■
Rail					
Horizontal Distance					
Off-Street or On-Street Bus Terminal Facilities	■	x	■	■	■
Vertical Alignment of Bus and Rail Routes to Reduce Horizontal Distance	■	■	■	■	■
Bus Ramps into Station	x	x	■	■	■
Vertical Distance					
Reduction of Vertical Distance	x	x	x	■	■
Reduction of Perceived Vertical Distance (elevators/escalators)	x	x	■	■	■

Table continued on following page.

Table 5-1 (Continued)

SUMMARY OF STUDY FINDINGS

Option	Operator Effort	Cost	User Satisfaction	Ridership	Revenue
THROUGH-ROUTING					
Bus					
Interlining or "Classic" Through-Routing	o	o	■	■	■
Single Route Through-Routing	o	o	■	■	■
Variable Through-Routing	■	o	o	o	o
"Trippers"	o	o	o	o	o
Overlap	o	■	■	■	■
Rail					
Route Consolidation	■	-x	-■	-■	-■
SCHEDULE COORDINATION					
Bus					
CBD	o	o	■	■	■
Trunk-Crosstown	o	o	■	■	■
Minor	o	o	o	o	o
Rail					
Rapid Rail-to-Bus	o	o	o	o	o
Bus/Commuter Rail	o	o	o	o	o
Rail/Rail	o	o	o	o	o

Table continued on following page.

Table 5-1 (Continued)

SUMMARY OF STUDY FINDINGS

Option	Operator Effort	Cost	User Satisfaction	Ridership	Revenue
DYNAMIC CONTROL					
Bus					
Alone	o	o	o	o	o
With Other Options	■	■	■	■	■
Rail					
Informal Holding	o	o	o	o	o
Formal Meeting	■	■	o	o	o
Formal Holding	■	■	o	o	o
TIMED TRANSFERS					
Bus					
Simple Timed Transfers	o	o	■	■	o
Pulse Scheduling	■	■	■	■	■
Line-Ups	■	■	■	■	■
Neighborhood Pulse	■	■	■	■	■
Rail	■	■	o	o	o
SCHEDULE ADHERENCE (+)	x	■	■	■	■
SERVICE FREQUENCY (+)	■	x	x	x	x
TRANSFER CHARGE (+)	o	o	-■	-o	o
USE OF TRANSFER SLIPS	o	■	o	o	o
Bus	o	■	o	o	o
Rail	■	x	o	o	o

Table continued on following page.

Table 5-1 (Continued)

SUMMARY OF STUDY FINDINGS

Option	Operator Effort	Cost	User Satisfaction	Ridership	Revenue
SCHEDULE INFORMATION	o	o	o	o	o
MARKETING	o	o	o	o	o

CODE: x Has large effect in most settings.

■ Effect varies substantially depending upon setting.

o Usually has a minor effect.

\- Negative effect in given impact area (e.g., -x in second column means major reduction in cost).

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