Title
Adaptive Transit: Enhancing Suburban Transit Services

Authors
Cervero, Robert
Beutler, John

Publication Date
2000-09-01

Adaptive Transit: Enhancing Suburban Transit Services

Robert Cervero
John Beutler

UCTC
No 424

The University of California
Transportation Center

University of California
Berkeley, CA 94720

The University of California Transportation Center

The University of California Transportation Center (UCTC) is one of ten regional units mandated by Congress and established in Fall 1988 to support research, education, and training in surface transportation. The UC Center serves federal Region IX and is supported by matching grants from the U S Department of Transportation, the California Department of Transportation (Caltrans), and the University

Based on the Berkeley Campus, UCTC draws upon existing capabilities and resources of the Institutes of Transportation Studies at Berkeley, Davis Irvine, and Los Angeles, the Institute of Urban and Regional Development at Berkeley, and several academic departments at the Berkeley, Davis, Irvine, and Los Angeles campuses Faculty and students on other University of California campuses may participate in Center activities. Researchers at other universities within the region also have opportunities to collaborate with UC faculty on selected studies.

UCTC's educational and research programs are focused on strategic planning for improving metropolitan accessibility, with emphasis on the special conditions in Region IX Particular attention is directed to strategies for using transportation as an instrument of economic development, while also accommodating to the region's persistent expansion and while maintaining and enhancing the quality of life there

The Center distributes reports on its research in working papers, monographs, and in reprints of published articles. It also publishes *Access* a magazine presenting summaries of selected studies For a list of publications in print, write to the address below

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program in the interest of information exchange The U S Government assumes no liability for the contents or use thereof

University of California Transportation Center

108 Naval Architecture Building
Berkeley, California 94720
Tel 510/643-7378
FAX. 510/643-5456

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the U S. Department of Transportation This report does not constitute a standard, specification, or regulation

Monograph 99-01

Adaptive Transit: Enhancing Suburban Transit Services

Robert Cervero and John Beutler

Report prepared for the University of California Transportation Center

University of California at Berkeley
Institute of Urban and Regional Development

CONTENTS

Tables, Boxes, Figures, Maps, and Photos

Tables

Boxes

Figures

Maps

Photos

Chapter One

Serving the Suburbs with Adaptive Transit

1.1 Introduction

Suburbia largely remains hostile territory for public transit in America and, indeed, much of the developed world. Transit's market share of every type of trip is steadily eroding outside of central cities virtually the world over. With trip origins and destinations spread all over the map, traditional fixed-route, fixed-schedule, radially oriented transit services are finding it increasingly difficult to compete with the private automobile.

Yet against this backdrop, some metropolitan areas both in the United States and abroad have responded to low-density development patterns by designing more flexible, market-responsive forms of mass transit Many strategies aim to eliminate, or at least marginalize, what is the scourge of suburban transit services worldwide – the transfer.

This study examines *Adaptive Transit* as a promising approach toward better serving suburban markets. Initially, Adaptive Transit is defined and classified. Case studies from both the United States and abroad are then used to examine experiences across ten different forms of Adaptive Transit. "Best case" examples are cited, where possible. In addition to describing the rationales and service features of different forms of Adaptive Transit, case reviews focus on evaluating performance impacts, particularly with reference to "control cases" for which traditional suburban services, in otherwise comparable settings, remain in place. Moreover, attention is given to matters of implementation. In most cases, the "software" (i.e., public policies) that accompanied the "hardware" (i.e., technologies and service innovations) was every bit as important in achieving success.

1.2 Struggling in Suburbia

Throughout North America, in much of Europe, and even in most developing countries, the private automobile continues to gain market shares of motorized trips at the expense of public transit systems. In the United States, just 1.8 percent of all person trips were by transit in 1995, down from 2.4 percent in 1977 and 2.2 percent in 1983.[1] Despite the tens of billions of dollars invested in new rail systems and the underwriting of upwards of 75 percent of operating expenses, travel shares for transit's bread-and-butter market – the work trip – have fallen. Nationwide, 4.5 percent of commutes were by transit in 1983; by 1995, this share had fallen to 3.5 percent.

Among the many factors held responsible for transit's decline, the steady decentralization of urban activities is toward the top of this list, if not the number one reason. Decentralization has spread out trip origins and destinations, making it increasingly difficult for linear systems, especially those focused on a single point (i.e., downtown), like conventional transit, to effectively serve travel desires. However, anti-transit land-use trends have not only involved the spreading out of points on a map. The very make-up of origins and destinations themselves have worked against transit. Increasingly, the site designs and land use configurations found in the suburbs are poorly suited to transit riding. Many new office and professional workplaces are situated in "parks", featuring vast green spaces that separate buildings, branch-and-loop road systems that complicate bus routing, and abundant, free parking. Many are devoid of such basic provisions as on-site bus shelters, bus staging areas, and even sidewalk networks. Contemporary shopping centers are often even less transit-friendly. Bus riders are sometimes dropped off on the periphery of shopping centers, forced to wade through a sea of parked vehicles to reach front entrances. The perimeters of many shopping malls do not even have sidewalks. Master-planned residential enclaves of suburbia are sometimes even worse offenders. Besides the loop-and-lollipop configurations of streets, increasing numbers are walled-off from surrounding areas, presenting physical obstacles to any kind of lateral movement.

1.3 Adaptive Transit

Suburbanization has not crippled transit systems in all instances. Some cities and regions have formed transit services that are holding their own against the automobile, in some cases even grabbing larger market shares of urban travel. These are places that have been superbly *adaptive*, almost in a Darwinian sense. Notably, they have found a harmonious fit between mass transit services and their cityscapes Some have done so by reshaping their built environments so that they are more conducive to transit-riding – namely by creating dense, urban-like nodes along linear corridors, and building rail networks to serve them. However, creating rail-oriented development has its limitations, not the least of which is the continuing preference of Americans, Europeans, and most others for low-density living. Moreover, rail transit is not a cost-effective option for many metropolitan areas under three million inhabitants.

Adaptive Transit is a polar-opposite response to New Urbanism, Transit Villages, and other popular design movements. Namely, it accepts, rather than trying to alter, low-density, market-driven patterns of growth. It responds by adapting mass transit services and technologies to better serve spread-out environs. It recognizes low-density development as an outcome of rising affluence and the preferred lifestyle of many; accordingly, transit services are adjusted and reconfigured to best serve this environment. And it is sensitive to political realities. There is apt to be far less resistance to reshaping transit services than to reshaping living and working environments. In a piece titled "The Marriage of Autos & Transit", Melvin Webber embraces the very essence of Adaptive Transit:

> If it's true that the automobile owes its tremendous success to its door-to-door, no-wait, no-transfer service, and if it's true that the structure of the modern metropolis is incompatible with large-vehicle transit systems ... I suggest that the ideal suburban transit system will take its passengers from door-to-door with no transfers and with little waiting.[2]

The challenges of designing mass transit to serve thinly spread development are immense, though not insurmountable. Suburbia produces seemingly random patterns of trip-making, akin to Brownian motion wherein movement is seemingly from anywhere to everywhere. Decentralization of jobs and retailing in many parts of the world has been largely responsible for the sharp growth in cross-town and lateral trip-making. Instead of traveling radially along well-defined corridors between suburbs and CBD, more and more commuters want to move tangentially, and are often forced onto facilities that were never designed or oriented to serve these movements. In the United States, the share of work trips both beginning and ending in the suburbs increased from 39 percent in 1970 to 52 percent in 1990.[3] In Greater London, suburb-to-suburb commutes have similarly eclipsed radial journeys to the central city as the dominant commute pattern [4]

A criticism of Adaptive Transit might be that by catering to low-density development, it reinforces and perhaps even perpetuates sprawl and unsustainable patterns of growth. On balance, we find this criticism unconvincing. To suggest that urbanization should be universally compact and transit-oriented is to ignore political realities and market preferences. While lifestyle preferences for low-density living might indeed press the limits of sustainability over the long run, the preferred way to attack the problem of sprawl is to pass on true social and economic costs to developers and consumers who build and live in these settings – in the form of sprawl taxes, higher fuel prices, and the like. Of course, exacting such charges can be even more elusive than containing sprawl. As long as there is underpricing of scarce resources, including land, and spread-out settlements as a consequence, a sensible option for some regions will be to adapt transit to better serve this pattern. It is important to keep in mind that what matters most about cities is people and places, not traveling. If anything, travel is something most people want to avoid. Our planning challenges lie with making cities and regions healthier, safer, and more enjoyable places in which to live, work, shop, and socialize Accordingly, transportation planning should be subservient to the broader community goals. Thus, we should not be creating urban environments to promote transit – this puts the transportation cart before the land-use horse. Rather transit should be serving land-use visions and realities, which in many cases means and will continue to mean spread-out development. In the United States, dozens of regions have opted to build light rail transit (LRT) systems in recent years under the belief that rail transit, in and of itself, provides for a more sustainable future. Unfortunately, most have allowed suburban growth – in the form of shopping malls, campus-style office parks, and large-lot residential tract housing – to turn its back on the LRT investments. The blunder of letting a vision of transit rather than land use dictate investment policy inevitably gets translated into poor ridership results. Transit investments that fail to lure motorists out of cars and into trains and buses will do little to conserve energy, reduce pollution, or relieve congestion.

1.4 Forms of Adaptive Transit

Adaptive Transit takes on one or more of the following service features:

- Flexibility in routing and scheduling
- Demand-responsiveness
- Near curb-to-curb delivery
- Comparatively fast operating speeds
- Real-time information, for operators and passengers
- Comfortable, convenient, and safe access and waiting environments

As noted above, what all forms of adaptive transit have in common is the minimization and marginalization of switching routes or vehicles – what North Americans call "transferring" and many Europeans call "interchanging". A popular expression used today in the transit industry is "seamless" services. It is well known within the transportation field that transferring is much despised, with some studies suggesting travelers perceive the physical act of switching vehicles taking three times longer than it actually does.[5] As much as anything, adaptive transit services aim to both expedite and reduce the perceived burden of transferring. Whether done through routing practices (e.g., route deviations), communications (e.g., passenger information systems), technologies (e.g., track-sharing), or choice of equipment (e.g., door-to-door vans), all forms of adaptive transit share a common goal of expediting and easing the process of changing routes or services, especially in the suburbs. In many ways, the challenges facing transit in suburban markets is analogous to those of goods movements in the global marketplace. The emergence of Just-in-Time (JIT) stock policies in manufacturing and trade has demanded that a near 0-error system of transfers be introduced.[6] With the in-sourcing and out-sourcing of goods and raw materials from all corners of the earth, transhipment between highways, railways, seaports, and airports must today be as efficiently and tightly timed as possible if multinational companies are to remain globally competitive. Increasingly, mass transit services are being held to similar standards.

Adaptive transit falls into three classes: (1) *Technological Innovations*; (2) *Bus-Based Service Innovations*; and (3) *Small-Vehicle, Paratransit Services*. Table 1.1 summarizes the types of Adaptive Transit within each class, and lists cities that have introduced these services and reforms. While admittedly there is some overlap between the classes, this three-way breakdown captures the gist of how adaptive transit services have evolved to date.

1.4.1 Technological Innovations

Technological innovations have increased the speed and flexibility of traditional transit services. Two types of technological innovations are Bus Rapid Transit services and Flexible Technologies, like track-sharing.

Table 1.1: Classes and Types of Adaptive Transit

Classes and Types	*Examples*	*Case Experiences*
A. TECHNOLOGICAL INNOVATIONS:		
1 Bus Rapid Transit	Busways, Priority Schemes	Curitiba (Brazil), Quebec (Canada)
2. Flexible Technologies	Track-Guided Buses, Rail Track-Sharing	Adelaide (Australia), Karlsruhe (Germany)
B. BUS-BASED SERVICE REFORMS:		
3 Seamless Transferring	Timed-Transfers, Coordinated Scheduling	Edmonton (Canada), Portland OR
4 Tangential Routing	Crosstown Surface and Express Routes	Houston TX, San Jose CA
5 Flexible Routing	Route Deviation, Dail-a-Ride	Ft Worth TX, Broward County FL
C. SMALL-VEHICLE SERVICE REFORMS:		
6 Shuttles	Home-End Shuttles, Work-End Shuttles	Contra Costa County CA, Albany NY
7 Circulators	Activity-Center Circulators	Montgomery County MD, Santa Clara County CA
8 Zonal Networks	Cellular Services,	Tidewater VA, Hamilton OH
9 Subscription Services	Vanpools, Club Buses	Seattle WA, Houston TX
10 Paratransit	Jitneys, Shared-Ride Taxis	Mexico City, San Juan PR, Miami FL

Bus Rapid Transit

Bus Rapid Transit, or BRT, attempts to emulate the operations of urban rail transit using comparatively inexpensive bus-transit technologies. The BRT concept continues to evolve, making any precise definition somewhat presumptuous. Regardless, BRT projects that have been introduced or are being advanced embody some combination of the service features outlined in Box 1.1 Perhaps most important are dedicated, exclusive rights-of-way that increase bus speeds. Because buses travel on average at only around 60 percent of the speeds of automobiles using the same street, any significant improvement in quality of service will require special reserved lanes.[7] Advanced technologies, signal prioritization, and off-vehicle fare collection are other important features of BRT.

Box 1.1

Bus Rapid Transit

- *Exclusitivity*: physical segregation
- *Advanced Bus Technology*: clean fuels, light-weight materials, low floors, advanced communications
- *Supportive Armature*: signal priorities, bus turnouts, curb realignments, automated vehicle location, dispatching, and routing systems.
- *Expeditious fare collection & boarding*: off-vehicle payment; smart cards

The most substantial and expensive form of BRT involves an exclusive, dedicated facility that only buses operate on. The Brazilian cities of Curitiba, Porto Allegre, and São Paulo, plus Ottawa, Canada, have introduced extensive and successful exclusive busway networks. São Paulo's busway has been credited with carrying upwards of 25,000 passengers per lane per hour, a figure that begins to match the passenger throughput of many underground metro systems.[8] In all of these cases, buses run swiftly, headways are short, and stops feature high platforms that expedite loading and unloading of passengers. Always, fares are collected prior to passengers boarding a bus, reducing vehicle dwell time by speeding up the boarding process. The end result is not only faster average speeds, but also more reliable, convenient, comfortable, and safer services. America's only significant dedicated busway is Pittsburgh's 6.8-mile system, whose ridership increased by 50 percent (from 20,000 to 30,000 daily) a decade after its 1983 opening, despite a decline in metropolitan population as well as absolute ridership levels over the same period.[9] Far more prevalent are HOV lanes that buses share with carpools and vanpools, such as the Shirley Highway in northern Virginia and the El Monte Busway (technically a three-plus-person HOV facility) in Los Angeles County. However, these are not true busways in that bus operating speeds and maneuvers are restricted by the presence of other vehicles. However, exclusive busways can be costly and disruptive in the absence of preserved rights-of-way. For this reason, some cities have sought to speed up buses short of building dedicated facilities. In the province of Quebec, Canada, both Montreal and Quebec City have introduced a series of priority measures that enable buses to avoid some of the traffic congestion on surface streets, including queue-jumper lanes, contra-flow lanes, shoulder lanes, and traffic signal prioritization. Both cities' experiences with BRT are reviewed in this report.

The nation that has made the most headway to date in advancing BRT is France. The Paris region (Ile-de-France) has embarked on the construction of a 170-km network of exclusive busways and bus lanes, covering a third of the radial and two-thirds of the circumferential routes in Paris's suburbs. The region's first busway, Trans-Val-de-Marne (TVM), opened in 1993 in a southern suburb of Paris. The new bus network will supplement an already extensive, 300-km network of exclusive bus lanes that traverse Paris's city streets. Nice, France's dedicated bus lanes are even more substantial than those in Paris, with concrete curbs physically segregating shoulder lanes from regular through traffic.

Within the past year, BRT has received considerable attention in the United States. In December of 1998, the Federal Transit Administration (FTA) solicited requests for proposals to participate in a federal BRT demonstration program; in June of 1999, ten communities were selected to participate in the federal BRT pilots.[10] The FTA is particularly interested in Eugene, Oregon's proposal, wherein an assortment of exclusive lane configurations is planned for on a 10-mile pilot corridor. Other elements of Eugene's proposed system include low-floor buses, small-vehicle feeders, signal prioritization at intersections, and comfortable, enclosed stations. Local transit managers estimate the investment will cost just 4 percent of what a comparable light rail system would have.[11] Another noteworthy demonstration project is planned for Northern Virginia, where two engineering firms, Bechtel and Raytheon, have offered to build and operate a 23-mile busway linking Washington's Metrorail system with Dulles International Airport in northern Virginia. The dedicated bus facility will lie in the median of the existing Dulles Access Road and will cost approximately $180 million to build, about a third the cost of extending Metrorail service.

Flexible Technologies

Another set of technology-based innovations have sought to make fixed-route services more flexible so as to shorten walk-access distances to and from transit stops. One approach involves track-guided buses, first introduced in Essen, Germany, and more recently applied in Adelaide, Australia. Also called O-Bahn, this technology relies on buses equipped with guide-rollers that steer the vehicles along dedicated tracks to achieve high speeds and efficiencies along mainline corridors. In both suburbs and core cities, vehicles exit the guideway and operate as regular surface street buses, functioning like distributors and circulators. In Karlsruhe, Germany, and several dozen other cities, light-rail transit vehicles have been transformed – both in terms of power sources and vehicle designs – so that they can operate not only on surface streets (like a tram) but also on regular railroad tracks (like a high-speed train). In Karlsruhe, the marriage of mainline and feeder functions in a single vehicle has eliminated the transfer for many rail trips.

A more recent example of flexible technology, first demonstrated on a test line in Caen, France, is Guided Light Transit (GLT). There, a hybrid vehicle (part trolley, part guided bus, and part traditional bus) is being developed that operates on a dedicated guiderail, drawing power from an overhead catenary When operating off-line, the vehicle is powered by a diesel motor. Its all-directional wheel service is being billed as "a snake on tires". Being designed, built, and operated by a consortium headed by Bombardier, the system will cost only US$14 million per km versus US$35 million per km for a state-of-the-art light rail system. GLT technology is being targeted at medium-sized cities which cannot support an expensive grade-separated light or heavy-rail investment. Nancy, France, expects to be the first city to initiate GLT services over an entire corridor, with the first segment of 10 km slated to operate by the end of the year 2000. GLT trains in Nancy will look similar to articulated light rail vehicles, except they will operate on pneumatic tires and will be guided by a single grooved rail.

More recently, the United Kingdom has gain prominence in the advancement of guided bus technologies. Leeds and Ipswich were the first British cities to introduce guide busways; in both cases, however, only short busway links were built to provide queue-jumper lanes around crowded street segments. More substantial is a driverless guided busway being planned as part of the Centre West urban redevelopment project in West London. Another cutting-edge guidance technology – a magnetic field generated by a low-level current passing through two parallel wires laid beneath the guideway – is being developed for the proposed Riverside Transit project along the north bank of the Tyne River in Newcastle. Tauted as "Bus on Rail", the system employs the same guidance technology successfully introduced on the tunnel transit system of the Channel Tunnel.

1.4.2 Bus-Based Service Reforms

The second class of Adaptive Transit involves the reconfiguration of traditional bus routes so as to more directly serve trip origins and destinations as well as reduce out-of-vehicle waiting and transferring times Three types of Bus-based Service Innovations are: Seamless Transferring, Tangential Routing, and Flexible Routing.

Seamless Transferring

As implied by name, seamless transferring makes the physical act of switching vehicles and routes as effortless as possible. The most prominent form is timed-transfer systems, first pioneered in Alberta, Canada's two largest cities – Edmonton and Calgary – and since adopted by many large bus transit systems in North America, including the Ottawa case reviewed in this report. In Edmonton, the regional bus system was completely overhauled in the mid-seventies to mimic the area's emerging cross-town and lateral commuting pattern. All services were reorganized around some two dozen transit centers, in addition to the main downtown terminus, with routes blanketing the city in a combined criss-cross and radial fashion. Today, anywhere from five to ten bus routes converge simultaneously on one of Edmonton's outlying transit centers every 20 to 30 minutes. Transit patrons scramble from one bus to another to make their connections, and almost like clockwork, buses depart three to five minutes later.

Many U.S. and Canadian cities have since tried to emulate Edmonton's successes. A recent survey of 88 U.S. transit operators found that 68 percent had some form of timed-transfer services; among properties with more than 350 buses, almost 90 percent used timed transfers.[12] Seattle has combined timed-transfer networks with "fixed in/flex-out" services, involving buses and vans that depart transit hubs at scheduled times, delivering passengers to any location within a service zone (the "flex" portion). After dropping off passengers, vans return to the hubs along a fixed route on local streets (the "fixed" portion).

The design and integration of transit centers is key to the success of creating seamless transfers. In most cities without extensive rail networks, transit centers are often located in or near shopping malls and other activity centers. Rail cities with timed-transfer bus services, like Portland, Oregon, typically rely on rail stations as transfer points.

Two forms of "seamless transfer" services are pulse and coordinated scheduling. With pulse schedules, buses arrive and depart transit centers at approximately the same time, akin to a pulse beat. Coordinated services operates more loosely. Here, bus schedules are not strictly set; rather, in light of the often circuitous roadways found in suburbia, buses aim to arrive at transit centers within more liberal time allotments, usually between 10 and 15 minutes. Portland's transfer program involves such coordinated scheduling.

Tangential Routing

Several cities have reconfigured bus routes to directly serve the suburb-to-suburb travel market. This often involves introducing a "freeway flyer" express service wherein buses operate along freeways (often segments of beltways) for the line-haul component of trips. In cities like Houston, tangential routes originate from park-and-ride lots. There, buses operate along High-Occupancy Vehicle (HOV) lanes for substantial segments. Other cities have sought to provide speed advantages to tangential routes by introducing skip-stop services. Besides Houston, other areas with tangential routes include San Diego, Riverside (California), Suffolk and Westchester counties (New York), central New Jersey, and metropolitan Washington, D.C. Metropolitan Washington's recently introduced tangential bus service, called "SmartMover", operates mainly along the beltway between Montgomery County, Maryland, and the mega-employment center of Tysons Corner in Fairfax County, Virginia. Currently, it attracts some 700 customers a day, up from 100 per day when it first started in 1998.

Flexible Routing

In some areas, buses do not strictly follow fixed routes, but rather deviate according to rider requests. Route deviation services allow drivers to make small detours, either along an entire route, a specific points, or designated checkpoints (Figure 1.1).[13] Areas with route deviation services available to the general public include Fort Worth TX, Broward County FL, Kansas City, Missouri, Winnepeg, Manitoba, and Prince William County, Virginia. In the case of Prince William County, a rapidly growing exurb south of Washington, D.C., vehicle tracking and real-time reservation systems have been introduced along with flexible feeder and circulation service to provide customers curb-to-curb services within an hour of a ride request. The flex-route feeder service, called OmniLink, allows buses to deviate as much as a mile and a half en route to Virginia Railway Express (VRE) commuter rail stations.

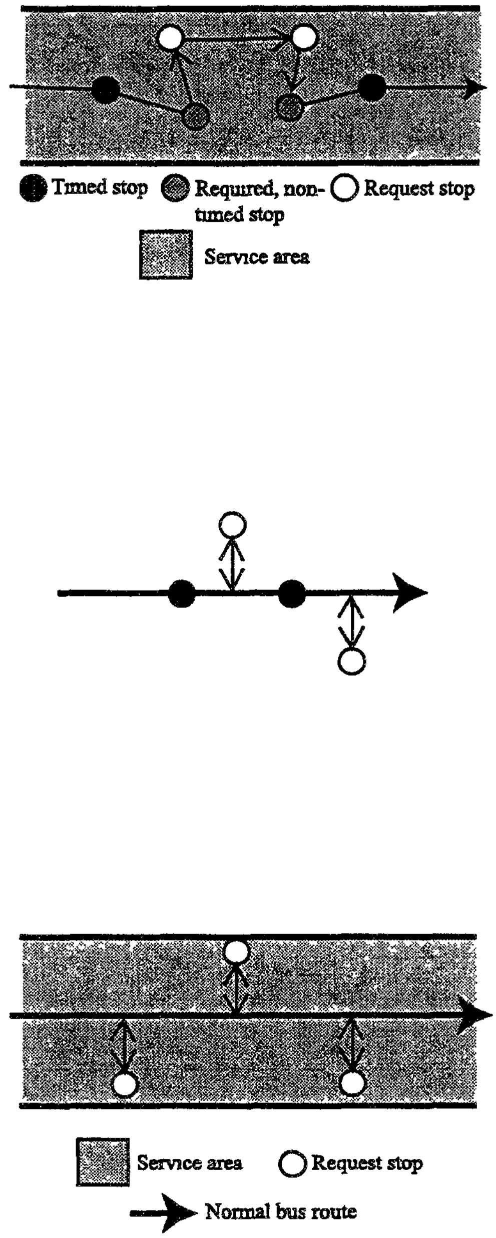


Figure 1.1. Forms of Route Deviation (Top) *Entire Route*: buses may leave a route at any point to pick up riders (requested by phone) or drop off riders (as requested by an onboard passenger) in areas adjacent to the service, as long as they return to the route at the point of departure, (Center) *Point Deviation* buses deviate from a designated route and schedule only at pre-determined locations (points), (Bottom) *Checkpoint*: buses visit fixed stops on a pre-determined time schedule, but deviate freely within the area or quandrant to pick up individuals along the way and return to the fixed point on schedule

Another form of flexible routing involves dial-a-ride (DAR) services. Here, small buses, and sometimes vans, respond to advanced telephone reservations by picking up and dropping off customers, door-to-door. Advanced request requirements vary, but in order to be reasonably competitive with the private automobile in non-captive markets, clients should not have to telephone in more than an hour in advance. It is the multiple passenger features of dial-a-ride services that lowers the per-passenger cost of dial-a-ride relative to taxi services. Dial-a-ride services are sometimes linked to fixed-route bus or rail services through timed-transfers. An example is the DART (Direct Access to Regional Transit) services in San Diego County, wherein vans and minibuses provide curb-to-station connections between suburban residents and regional light and commuter rail lines. Studies show dial-a-ride services to be generally cheaper and more cost-effective than fixed-route suburban services, and while this is attributable partly to higher load factors relative to vehicle size, it is also largely a function of dial-a-ride services being typically contracted out to private operators.[14]

1.4.3 Small-Vehicle Service Reforms

The final class of Adaptive Transit exploits the inherent routing and speed advantages of small vehicles to better serve suburban markets. Much of the success of small-vehicle services lies in their flexibility and adaptability. Besides being more human-scale, small vehicles, like vans, jitneys, and minibuses, offer a number of potential operating advantages over bigger vehicles: they normally take less time to load and unload, they arrive more often, they stop less frequently, they are more maneuverable in busy traffic, and, studies show, passengers tend to feel more secure since every one is closer to the driver.[15]

Shuttles

Shuttle services provide feeder connections to mainline bus or rail routes. They generally function as many-to-one or few-to-one services, and are best distinguished by which end of a trip they focus on. The "one" end of the trip tends to be a rail station; thus, shuttles are most prominent in large metropolitan areas. Home-end shuttles typically link residential neighborhoods with mainline transit stops. Because they serve the general public, home-end shuttles are usually sponsored by public transit agencies (though often competitively contracted out). Destination-end shuttles normally link a rail station and a suburban activity center. Usually the activity center is a large workplace or employment concentration, such as in the case of Contra Costa County reviewed in this report. In such instances, employers normally sponsor these services. In a handful of areas, like Montgomery County, Maryland, and Albany, New York, destination-end shuttles principally serve shopping malls.

Studies show that well-designed shuttle services can be an important inducement to ridership on mainline transit services. In the case of 25 shuttle routes that tie into the CalTrain commuter rail line along the peninsula in San Mateo, Santa Clara, and San Francisco counties in northern California, a 1996 survey revealed that 88 percent of passengers who used shuttles would not have patronized the rail service in the absence of these feeder connections. Over half the shuttle riders previously drove to work along before shuttle services were initiated, eliminating over 1,700 single-occupant vehicle trips during peak hours.[16]

Circulators

Some suburban areas have introduced circular routes that either operate within or tie together activity centers, like shopping malls, medical complexes, sports centers, and college campuses. Many circulator routes feed into mainline linear bus routes. Because vehicles often go into local neighborhoods and operate on secondary roadways, vans and minibuses are often used. Trips on circulators are usually short; thus, headways likewise need to be relatively short. Activity-center circulators typically provide midday mobility for suburban workers, either operating within edge cities or connecting employment centers with nearby shopping plazas. Two cases reviewed in this report are drawn from Houston, Texas, and Contra Costa County, California.

Zonal Networks

A version of synchronized services geared to small vehicles is zonal networks. Recognizing that vans and microbuses are best suited to relatively small geographic catchments, zonal networks co-time the arrival of small vehicles operating within zones and large vehicles operating between zones. Within-zone services function more or less as circulators, whereas between-zone services emulate regional timed transit services. Thus, like other forms of Adaptive Transit, zonal networks involve the "seamless" integration of feeder and mainline services, though focusing on the feeder (i.e., collection and distribution) ends of trips. An example is in Tidewater, Virginia, which has created a "direct-transfer" network modeled after Edmonton's timed transfer network. There, feeder vans operate within cellular zones, and are linked to transit centers and bus transfer points via radio correspondence. Before and after comparisons show that good timed-transfer connections across zones reduced crosstown bus journeys by as much as 70 percent compared to travel times prior to service improvements.[17] In Hamilton, Ohio, fixed route buses have been replaced by flexibly routed minibuses that circulate within designated wedges, or cells, of the city. Travel between wedges is made on mainline transit routes and from a downtown transfer center. Orange County CA has created a similar zonal-based system, though using flexible DAR in lieu of fixed-route vans

Subscription Vans and Minibuses

Some U.S. transit agencies offer services to specific clients on a subscription (monthly fee) basis, typically operating vans and minibuses between suburban residential neighborhoods and large employment centers. In 1993, Seattle Metro operated over 500 vans, which represented almost 40 percent of all transit-agency sponsored vanpools in the country. In the United States, the average publically sponsored vanpool recovered 60 percent of operating costs through fares, relatively high compared most bus systems (though substantially below the high levels of earlier decades when private subscription services often generated profits).[18] Experiences with Houston's subscription van services are reviewed in this report.

Paratransit

Globally, the most popular form of small-vehicle, flexibly routed services are privately owned and operated jitneys and microbuses, commonly referred to as paratransit. Like DAR, they provide door-to-door service, or something close to it. Jitneys and commercial vans have over the years become vital mobility options in many developing countries, filling in gaps left unserved by public transit systems and providing efficient feeder connections into rail stations. The archetypical service consists of a constellation of loosely regulated owner-operated collective-ride vehicles that follow more or less fixed routes with some deviations as custom, traffic, and hour of day permit. This characterizes the paratransit sectors of Mexico City and San Juan, Puerto Rico, both reviewed in this report.

Although banned in most wealthy countries, a handful of U.S. cities today allow private minibus and jitney operators to ply their trade as long as they meet minimum safety and insurance requirements. New York City has the largest number of privately operated van services of any American city – an estimated 3,000 to 5,000 vehicles (seating 14 to 20 passengers) operate, both legally and illegally, on semi-fixed routes and variable schedules to subway stops and as connectors to Manhattan. Surveys show that over three-quarters of New York's commuter van customers are former transit riders who value having a guaranteed seat and speedy, dependable services. Miami also has a thriving paratransit sector that caters mainly to recent immigrants from Cuba and the West Indies who find jitney-vans a more familiar and congenial form of travel than buses. Today, virtually all U.S. cities allow private shuttle vans to serve airports

A particularly promising form of paratransit marries advanced information technologies and small-vehicle service to form a type of "smart paratransit". Germany has experimented with automated forms of demand-responsive transit using centralized computers to link waiting customers with flexibly routed buses and vans.[19] In Winston-Salem, North Carolina, vans equipped with automated vehicle locator (AVL) transmitters and on-board terminals are today used to provide door-to-door, real-time services for elderly clients. And in Prince William County, Virginia, similar types of smart paratransit provide feeder links to commuter rail stops for the general population.

1.5 Report Organization

This report relies upon ten case studies to examine and evaluate experiences with different forms of Adaptive Transit, both in the United States and abroad. Cases were chosen, where possible, to highlight best practices, though in many cases the jury is still out regarding the effectiveness of the services introduced. Other factors involved in selecting cases included the availability of reliable data and control sites as well as the willingness of local transit officials to provide in-field assistance.

It should be noted that some of the most ambitious efforts to date to create Adaptive Transit have been targeted at specific markets, most notably transportation-disadvantages groups like the elderly and, more generally, clients of ADA (Americans with Disabilities) programs However, our report focuses exclusively on experiences with Adaptive Transit services that are available to the public at-large since transit's future livelihood in the suburban marketplace will depend crucially on providing high-quality services that are attractive to the general populous.

Why was the case approach adopted in this study, one might ask? The principal reason was that there were insufficient numbers of cases, not to mention resources, to conduct a subject-focused study of each form of Adaptive Transit. Moreover, in the course of carrying out this research, it became evident that most case candidates had introduced multiple forms of Adaptive Transit innovations, making it difficult to isolate the unique effects of a particular approach. Indeed, one of our conclusions is that different forms of Adaptive Transit generally work better in combination than on their own. Accordingly, materials are organized by case-study areas, either cities (or combinations of cities) or urban counties. Figure 1.2 lists the study's ten cases, along with the different types of Adaptive Transit innovations introduced in each place. Experiences in some places, like Adelaide and Karlsruhe, focus on a specific type of Adaptive Transit, notably flexible technologies In other cases, such as Houston and Contra Costa County, a wide array of approaches have been introduced. In the concluding chapter, we synthesize the findings across cases to draw policy insights and conclusions.

In view of this study's dependence on cases, a few words should be said about the pros and cons of this approach. On the plus side, cases are contextually rich and concrete. When well presented, cases can illuminate complex, underlying social and political dimensions that are difficult to convey any other way. And cases often resonate with politicians and the general public, something which all too often scholarly works in the transit field have failed to do. Research shows that cases are usually far more accessible and meaningful to those whose opinions ultimately matter the most, elected officials. Politicians often rely on anecdotes to drive home points. Thus they are more inclined to listen to cases, in part because voters and their constituents often do. An interesting study of urban poverty in Boulder, Colorado, showed convincingly that case-wise analysis is more effective at influencing political outcomes than is variable-wise analysis based on conventional statistical techniques.[20] The research demonstrated that the effective use of cases can improve the assimilation, recall, and recognition of data among policy-makers who are given priority-setting tasks. Scholars tend to think in terms of variables – e.g., studying how multiple factors, like gasoline prices, urban densities, and transit modal splits, track each other over time. Politicians and lay-persons think more in terms of cases – e.g., what do experiences across several places tell us about a phenomenon?

Of course, a danger of cases is that they are unique, sometimes the result of peculiar circumstances. Thus, there is the risk of over-generalization. The popular press is littered with such examples – the uncovering of a "welfare queen" as "proof" that those on public assistance are out to milk the system, the reporting of businesses shortchanging customers as a condemnation of corporate America, and so on. For these and other reasons, all cases, including the ones presented in this report, should be carefully weighed in terms of what is generalizable and relevant and what is not. We try to be conscientious of this in the concluding chapter.

Classes and Types of Adaptive Transit

Cases:	BUS-BASED SERVICE REFORMS			TECHNOLOGICAL INNOVATIONS		SMALL-VEHICLE SERVICE REFORMS			
	ST	*TR*	*FR*	*BRT*	*FT*	*S*	*C*	*SS*	*P*
Houston, Texas		X				X	X	X	X
Albany, New York		X				X			
Kansas City, Missouri			X						
Contra Costa County, California			X			X	X		
Winnipeg, Canada			X			X			
Ottawa, Canada	X			X					
Montreal & Quebec, Canada				X					
Adelaide, Australia					X				
Karlsruhe, Germany					X				
Mexico City & San Juan, PR			X	X					X

Key.
BRT = Bus Rapid Transit
FT = Flexible Technologies
ST = Seamless Transferring
TR = Tangential Routing
FR = Flexible Routing
S = Shuttles
C = Circulators
ZN = Zonal Networks
P = Paratransit

Notes

1. Sources Urban Mobility Corporation, The 1995 Nationwide Personal Transportation Survey, *Innovation Briefs*, Vol. 8, No. 7, p. 1, 1997, A Pisarski, *Travel Behavior Issues in the 90's* (Washington, D.C.: Federal Highway Administration, U.S Department of Transportation, 1992)

2. M. Webber, The Marriage of Autos & Transit. How to Make Transit Popular Again, *Access*, Vol 5, p 31, 1994

3 A. Pisarski, *Commuting in America II: The Second Report on Commuting Patterns and Trends* (Landsdowne, Virginia: Eno Transportation Foundation, 1996).

4. M Breheny, Counter-urbanisation and Sustainable Urban Forms, *Cities in Competition· Productive and Sustainable Cities for the 21st Century*, J Brotchie, M Batty, E.Blakeley, P. Hall, and P Newton, eds. (Sydney: Longman Australia, 1996).

5. M Wachs, Consumer Attitudes Toward Transit Service. An Interpretative Review *Journal of the American Institute of Planners*, Vol. 42, No 1, 1977, pp. 96-104.

6. N. Harris, The Emerging Global City: Transport. *Cities*, Vol 11, No. 5, 1994, pp 332-336.

7. K. St Jacques and H. Levinson, *Operational Analysis of Bus Lanes on Arterials* (Washington, D C. Transportation Research Board, Transit Cooperative Research Program, Report 26, 1997), Federal Transit Administration, U.S. Department of Transportation, *Issues in Bus Rapid Transit* (Washington, D.C . Federal Transit Administration, 1999).

8 N. Smith and D Hensher, The Future of Exclusive Busways: The Brazilian Experience. *Transport Reviews*, Vol. 18, No. 2, 1998, pp. 131-152.

9. S. Vernick, Port Authority of Allegheny County Busway System, *Progress: Surface Transportation Policy Project*, September 1995, p. 4.

10 The ten cities (or projects) are: Boston, MA, Charlotte, NC, Cleveland, OH, Dulles Corridor, VA, Eugene-Springfield, OR; Hartford-New Britain, CT; Honolulu, HI, Miami, FL, San Juan, PR; and Santa Clara County, CA.

11 Federal Transit Administration, 1999

12 R. Cervero, Making Transit Work in the Suburbs. *Transportation Research Record*, Vol 1451, 1994. pp 3-11.

13 Interlining involves buses switching from one route to another when suburban terminuses are reached, so as to minimize deadheading and empty back-hauling and thus increase service-efficiency (route kilometers per total vehicle kilometers of service). Checkpoints are locations which serve the dual purposes of providing interchange points for passenger transfers and for monitoring schedule adherence and on-time performance. Checkpoints generally connote transfer locations for which the schedules of intersecting buses are not necessarily closely coordinated, as with timed transfer systems

14 A. Rufolo, J. Strathman, and Z. Peng, Cost Effectiveness of Demand Responsive Versus Fixed Route Transit Service. Portland, Oregon Case Study (Washington, D.C.· Paper presented at the 76th Annual Meeting of the Transportation Research Board, 1997), Urbitrans Associates, Inc., in association with Multisystems, Inc., SGG Associates, Inc., and Robert Cervero, *Improving Transit Connections for Enhanced Suburban Mobility* (Washington, D.C Transportation Research Program, Transit Cooperative Research Program, TCRP B-6, 1997)

15. R. Cervero, *Paratransit in America: Redefining Mass Transportation* (Westport, Connecticut Praeger, 1997)

16 Peninsula Corridor Joint Powers Board, *CalTrain Shuttle Program Plan· Using Shuttle Bus Service to Improve Connections to CalTrain Stations* (San Carlos· Peninsula Corridor Joint Powers Board, 1997).

17. J Becker and F. Spielberg, *Implementation of a Timed Transfer Network at Norfolk, Virginia* (Norfolk Tidewater Regional Transit, 1998)

18 *Ibid*

19. Called Ruf-Bus and first initiated in Friedrichshafen, Germany, patrons enter a three-digit code corresponding to the their destination transit stop. Based on where transit vehicles are within the system, a central computer displays the scheduled arrival time of a bus or van that will take them to their destination. Patrons can either accept or reject the pickup offer A central computer relays information on all accepted pickups to computer terminals on-board assigned vehicles Ridership rose dramatically following the introduction of Ruf-Bus services, but because of high operating costs and Germany's rising automobile ownership and usage, the system has been cut back in recent years. See R. Behnke, *German 'Smart-Bus' Systems: Potential Application in Portland, Oregon* (Washington, D C. Federal Transit Administration, U.S. Department of Transportation, 1993)

20. R. Brunner, J. Fitch, J Gassia, L Kathlene, and K. Hammond, Improving Data Utilization The Case-Wise Alternative. *Policy Sciences*, Vol 20, No. 4, 1987, pp 365-395

PART ONE

BUS-BASED SERVICE REFORMS

Part One examines experiences in four case-study areas where the focus of adaptive transit improvements has been on bus-based service reforms: (1) Houston, Texas; (2) Ottawa, Canada; (3) Québec Province, Canada; and (4) Contra Costa County, California.

Chapter Two

Dedicated Lanes, Tangential Routing, and Small-Vehicle Shuttles: Houston, Texas

2.1 Synopsis

In sprawling Houston, Texas, one finds a diverse array of non-traditional transit services that seek to better accommodate travel demands for destinations other than the downtown. Houston has not been shy in experimenting with new types of services, and in a number of instances, the efforts have paid off. Line-haul transit operations are well-served by the nation's largest HOV network. Park-and-ride lots and transit centers provide connection points where carpools and neighborhood feeders tie into express bus runs. However, the HOV-feeder bus arrangement is best suited for radial trip-making. Recognizing this, the regional transit operator, METRO, has introduced a myriad of other supplemental services, most notably a circumferential route, cross-town and tangential bus routes, shuttle runs, activity-center circulators, and even contracted jitney services. Most of the small-vehicle operations involve public-private co-participation -- either in the form of joint financing, or competitively contracted services. METRO, moreover, has emerged as a national leader in developing advanced transit technologies, including on-board navigational aids, vehicle guidance using forward-looking radar, and real-time information systems. Houston represents an exemplary case in terms of planning inputs and efforts; however, whether these initiatives will substantially pay off in the long term remains to be seen. Regardless, Houston is a city where the match between regional transit services and regional settlement patterns is far better than in most place. This has to bode well for the future of transit in Texas's largest city.

2.2 Making Transit Work in Houston

Houston, Texas, is a city where public controls over land uses and property development have never been popular. Among U.S. cities, it alone shuns zoning. Low-density, spread-out development has become a Houston way of life. If there is a U.S. city where adaptive forms of transit might be particularly suited, it is Houston. And indeed it has been in Houston where some of the greatest headway has been made in launching new types of transit services that are sensitive and responsive to scattered, low-density patterns of development. Houston today boasts America's largest High-Occupancy Vehicle (HOV) network, one that is eminently well-suited to the spread-out lay of the land. Houston has also experimented with as many forms of tangential bus services and small-vehicle circulators as anywhere. And advanced technology has gained prominence in Houston's transit planning, with METRO emerging as a national leading in developing automated transit guidance systems as well as leading-edge passenger information systems.

Houston is one of the few U.S. metropolitan areas where public transit's market share of commute trips has been on the rise. From 1980 to 1990, transit's share of work trips rose from 2.0 percent to 3.6 percent, the fastest percentage increase in the country.[1] Granted, it started from a very small base, so there generally was only one direction to go – up. Yet, it is also true that greater Houston is implanting a regional transit system, step by step, that is more in harmony with the regional landscape than most American metropolises can lay claim to. Rising ridership – today two-and-a-half times what it was in 1980 – is a direct outcome.

In 1982, Houston was second only to Los Angeles in traffic congestion. Over the past 15 years, the region has invested upwards of a billion dollars annually on massive road improvements, mostly financed by public bonds backed by toll revenues. Congestion has consequently fallen, despite rising employment and traffic volumes, one of only three U.S. metropolitan areas where this has been the case. From 1980 to 1990, average freeway speeds increased from 38 mph to 46 mph (61 kph to 74 kph).[2]

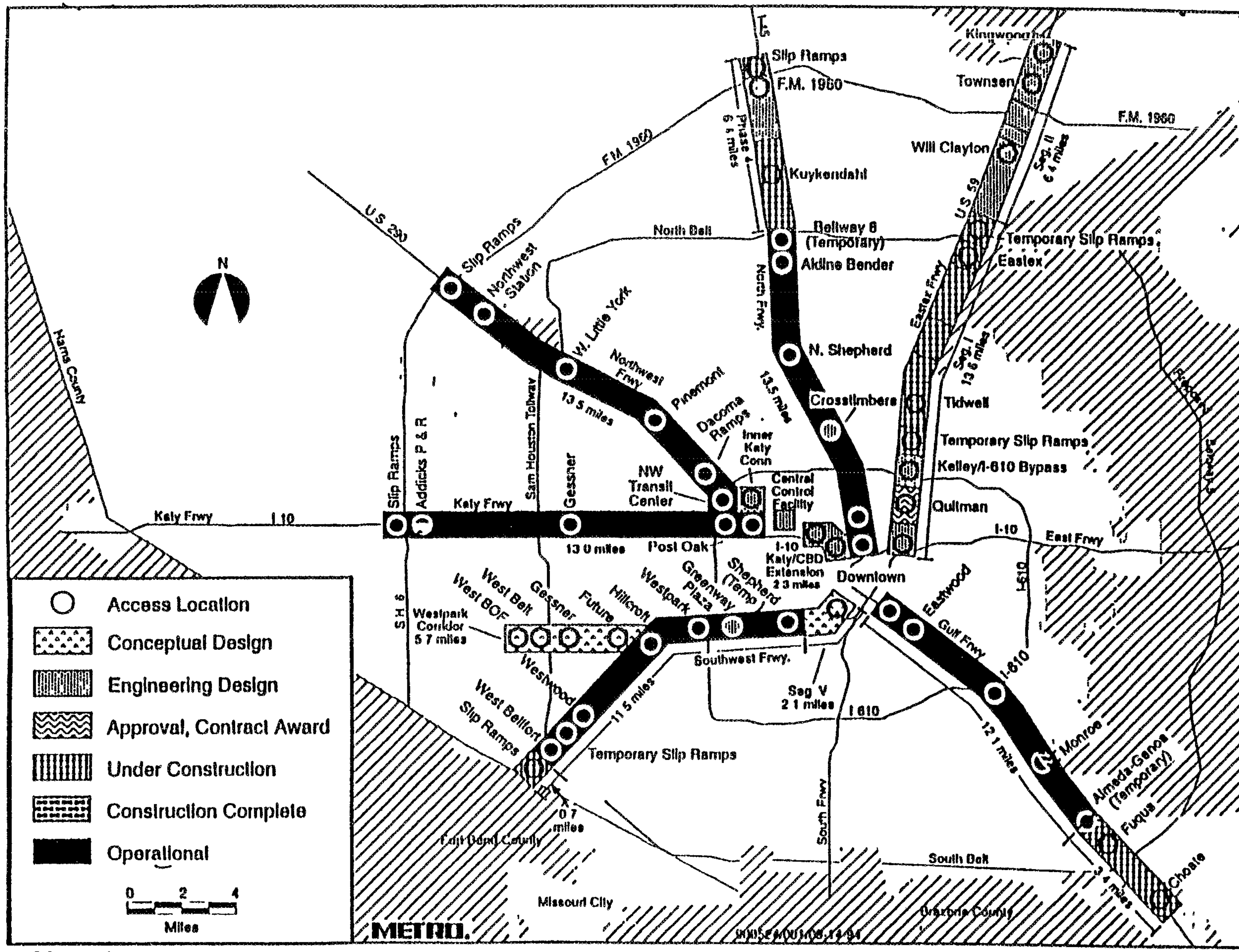
The needs of transit riders have not been overlooked, however. During the 1990s, transit has received 21 percent of all monies spent on upgrading transportation, even though it claims but 2 percent of the travel market.[3] A dedicated sales tax generates around $250 million annually for transit.[4] Original plans called for building a massive heavy rail system, but they were rejected by voters in 1973 and 1983. A light-rail proposal was gathering steam in the early 1990s when the former chairman of the regional transit agency (METRO), Bob Lanier, decided to run for mayor, largely on the platform of scrapping rail in favor of a more cost-effective, bus-based alternative. Upon winning the mayoral seat, Lanier moved quickly in designing a transit system suited to Houston, instead of the other way around. Under Lanier's leadership, Houston has taken on the mantle of America's premier example of Adaptive Transit.

2.3 Transit in a Polycentric Metropolis

While overall densities in Houston and its surroundings are low, the area is curiously also a land of subcenters. Greater Houston probably has more widely dispersed activity centers – some 22 at last count – than anywhere else in the world.[5] The Uptown/Galleria area claims some 26 million square feet (2.4 million m^2) of office space, more than downtown Denver. Other Mega-centers include the Texas Medical Center (the world's largest medical complex with over 60,000 workers), the Energy corridor along the Katy freeway, and the Greenway Plaza area.

Subcentering set the stage for designing a transit network suited to serving scattered trip origins and destinations. At the core of Houston's all-bus system is the HOV network, designed mainly to funnel suburbanites to downtown jobs via bus, vanpool, or carpool (Map 2.1). There are currently 108 kilometers of HOV lanes in the medians of five freeway corridors; the system is to expand to 165 kms and seven corridors by the year 2000.[6] HOV lanes are reversible, operating in one direction only – downtown-bound in the morning and outbound in the evening (Photo 2 1). Fly-over ramps link 24 park-and-ride lots to the HOV facilities.[7]

While technically an HOV facility, METRO's planners prefer to think of the facility as a dedicated busway that accepts smaller "transit vehicles" – vans and packed cars – to exploit available capacity. In 1991 dollars, it cost around $4 million per kilometer to build, about half as much as no-frills light-rail investments in San Diego, Portland, and San Jose.[8] Economies have partly accrued from adding links in conjunction with freeway expansion projects as opportunities



Source Metropolitan Transit Authority of Harris County (METRO), 1996

Map 2.1. Houston's HOV Network, 1996

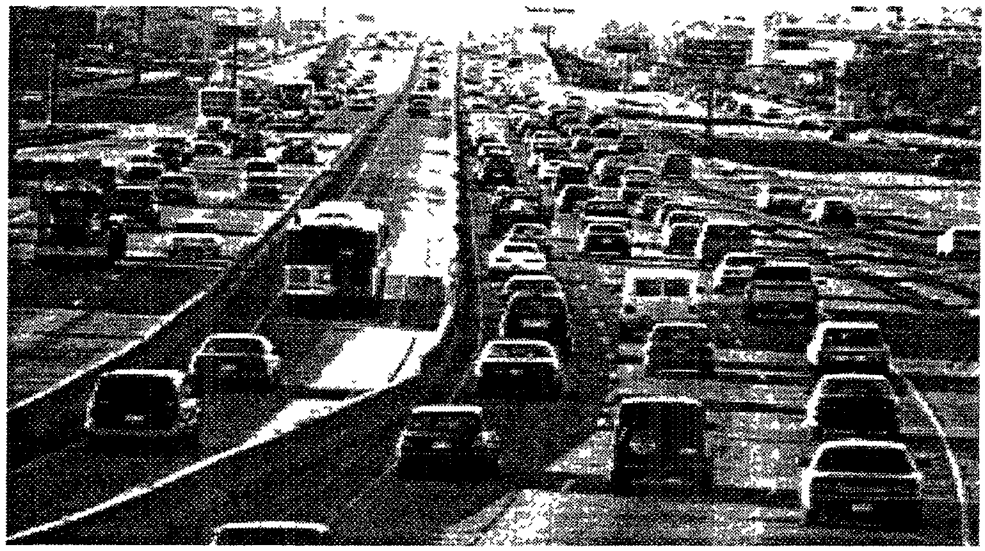


Photo 2.1. Bus and Carpools Share HOV Lane Houston

have arisen. Because average speeds more than doubled for buses that use the facility, operating costs have also fallen, by an estimated $5 million annually (in 1991 currency).

Cars with multiple occupants make up 94 percent of the 35,000 vehicles that use the HOV lanes each day.[9] Buses and vans each make up 3 percent. However, buses account for 34 percent of the daily passenger throughput of 80,000. And on the North (Interstate-45) HOV lane, the majority of people traveling are aboard buses. High ridership is mainly attributable to time savings – average bus speeds nearly doubled, from 26 mph to 49 mph, among express routes that switched to HOV facilities.[10] The Texas Transportation Institute estimates that the HOV lanes are producing throughputs of 72 to 280 percent above that of comparable general-purpose freeway lanes. In all, about 5 percent of the region's workforce uses the HOV lanes each workday.

The biggest benefit of the HOV is travel-time savings. Freeway travel averages 24 mph during rush hours, while HOV traffic speeds are typically 50 to 55 mph. Buses operating on HOV lanes enjoy typically save 8 to 12 minutes in travel time over what they would incur if they traveled on regular freeway lanes. (Express bus passengers *perceive* even greater time savings.) In return for faster service, passengers pay a premium that is typically two to four times higher than what regular METRO bus users pay per mile of travel. Patrons seem more than happy to pay the surcharge. Well over half of HOV lane users polled by the Texas Transportation Institute (TTI) report that they chose to carpool or patronize transit because of the existence of an HOV lane [11]

Aided by the HOV lanes and often subsidies from employers, vanpools have become an important feature of the local transportation scene – an entrepreneurial, small-vehicle form of mass transportation well adapted to spread-out development. In 1990, 15 percent of commuters were in vanpools or carpools, one of the highest rates in the country.[12]

2.4 Houston's Adaptive Transit

Metropolitan Houston's Adaptive Transit services fall into three categories. locals; express; and specialized. Locals function like regular bus routes, serving short-hop neighborhood trips. Express routes provide direct, peak-hour connections, mainly along the HOV lanes, to downtown and suburban centers. To aid transfers between local and express routes, there are presently 14 partially enclosed transit centers (complete with seats, telephones, route information) and plans for five more. Over half of local bus routes stop at a center.

The clientele of local versus express services differ markedly. Locals serve mainly transit-dependents (only 28 percent have access to a car) who walk-and-ride (93 percent). Express routes serve mainly choice riders (93 percent have access to a car) who park-and-ride (92 percent).[13] Park-and-ride connections to express runs tend to be fast and efficient. At the Addicks Park-and-Ride lot off the Katy Freeway HOV lane, articulated buses depart every 3 minutes during rush hour.

Houston's radial HOV arrangement provides superb services to the CBD; however, for other destinations routes tend to be circuitous. To reach the Uptown/Galleria or Greenway Plaza areas by express bus, for example, requires passengers to first go downtown. Presently, 29 percent of downtown workers arrive by bus, compared to just 7 to 8 percent of workers in the Uptown and Greenway areas. The one-way operation of HOV lanes compromises the ability to provide reverse-commute and cross-town express services

In an all-out campaign to better serve non-radial trips, Houston has in recent years introduced a number of unorthodox services. While some have struggled financially, they represent a willingness to take risks and test unchartered waters. The seven specialized, non-traditional services listed below are emblematic of Houston's unique approach toward designing Adaptive Transit.

(1) Circumferential Routes. Houston has introduced the nation's only true circumferential bus route – the TC Flyer which circumnavigates the Interstate-610 inner beltway, interconnecting the Texas Medical Center, Uptown Galleria, and Greenway Plaza. Operating on 15-minute headways throughout the day, the service was carrying some 900 passengers a day in 1996. However, because the TC Flyer runs so frequently, costs are relatively high, producing deficits of $23 per passenger in 1996.[14] For this reason, the future of the TC Flyer is in question. Until a dedicated bus lane is provided on the inner beltloop, local planners contend, the circumferential service will not achieve a sufficient speed advantage to lure sufficient numbers of motorists into buses.

(2) Tangential Routes: METRO has experimented with several cross-town express connections between park-and-ride lots and suburban centers. The most successful routes serve the Texas Medical Center (TMC), where 14 percent of workers commute by bus, by far the highest market share of all Houston edge cities. In all, 15 bus routes, most of which operate laterally (rather than radially to or from downtown) connect TMC with six transit centers, five park-and-ride lots, and a variety of residential neighborhoods in all parts of the city. Transit's success at the TMC stems partly from the demand-responsiveness of tangential services, but also because TMC has a fairly transit-supportive built environment

Compared to other subcenters, parking is expensive at TMC, comparable to what it costs in downtown Houston.[15] Moreover, parking garages lie on the periphery, whereas buses provide near-door delivery. Most TMC employers underwrite commuting expenses of employees who take transit or ride-share. TMC also has an integrated pedestrian network, including second-storey skywalks, that enhances the transit-riding experience.

(3) Transit Centers and Coordinated Transfers. METRO currently has 15 transit centers, with plans to open five more in the near future, including one downtown. Four regional transit centers are connected to the HOV system and are served by park-and-ride commuter bus routes, while the remainder connect local and express service from neighborhoods to the larger region. An array of buses (40-feet long, 30-feet long, and minibuses) feed into transit centers on schedules that are reasonably well coordinated with express services, typically resulting in a 3- to 4-minute peak period wait and about twice as long a wait in the off-peak. Besides providing a safe, enclosed place to transfer between local and express buses, the centers also provide a full array of bus route and schedule information, telephones, and (in the case of some) real-time information on expected arrival times.

(4) Subscription Services. A number of private subscription buses supplement METRO express services. Employers at Greensport, a small edge city north of downtown, sponsor several subscription services that use HOV lanes. The Woodlands, a master-planned new town 40 km north of downtown Houston, supports subscription services that cater to both employees and residents. More recently, the public sector has shown an interest in devising subscription services that reward loyal customers METRO's Board of Directors has endorsed a subscription bus program that would provide a $2.50 per trip subsidy for regular long-distance commtuers, with fares based on METRO's distance-based fare structure. While approved by the board, this publicly sponsored subscription service has been placed on hold for financial reasons.

(5) Vanpools. Some 2500 vanpools, among the largest fleet anywhere, operate throughout greater Houston, providing door-to-door services and filling in gaps left over by the bus system. Many are sponsored by employers. METRO itself sponsors over 100 vanpools that serves 35,000 monthly trips, most focused on suburban employment centers. METRO provides subsidies of anywhere between $10 and $35 per month for each vanpool, depending on employer subsidy support.[16] Vanpools have proven to be a cost-effective alternative to non-radial bus runs. Their per passenger subsidy of under a dollar is just half that of comparable park-and-ride express bus runs.[17] The sharing of driving duties among vanpool participants accounts for part of the cost savings.

(6) Midday Circulators. A deterrent to riding transit to suburban job sites is the restricted ability to get around in the midday. In response, METRO and employers co-sponsor midday shuttles that circulate within Uptown/Galleria, TMC, and the Greenpoint areas. In all instances, services are free. At the TMC, circulator buses run from 5:00 a.m. to midnight, with 2½- to 5-minute headways during peak hours. The TMC circulator handles some 8,000 passengers per typical weekday. While circulators are fairly expensive on a per-mile basis, Houston businesses support them not only because they relieve the demand

for expensive structured parking but also because they are perceived to provide a marketing edge to office projects that are served.

(7) Jitneys. In 1995, Houston's city council opened the marketplace to private jitneys, lifting restrictions on fares and services. (Besides meeting driver and vehicle fitness standards, the only restrictions are that jitneys cannot stop at METRO stops and vehicles can be no older than five years.) This has unleashed competition, something sorely needed in suburban markets. Seeing the handwriting on the wall, METRO decided to get a step on jitney entrepreneurs by contracting out supplemental van-size services, called FasTrak, for an 8-km stretch of the Westheimer Boulevard corridor.[18] Several other corridors are planned for jitney services. Jitney contractors can pick up all passengers who flag the jitney along a route and carry passengers to their destination within a permitted area. Jitney operators must operate between 6 and 9 a.m. and between 3 and 6 p.m., but are also allowed to ply their trade any other times of the day and week, as they see fit.

2.5 Future Directions and Technologies

While Houston may never be a place where mass transit captures a large share of vehicle trips, it nonetheless is a region where respectable enough mass transit services are being introduced that very well could make a difference. Many things are working in transit's favor in Houston. One is a fairly clear vision among officials and the general populous about what kind of city they want to be. Houston's long-range plan, Access 2010, calls for a balance of capital-intensive roadway and transit improvements. While it is largely left to the marketplace to determine where and by how much growth occurs, the plan provides a clear statement of where future transportation investments will be targeted. Importantly, it preserves rights-of-way and secures funding for proposed projects. In addition to a vision, Houston has benefitted from a visionary, Bob Lanier. His unbending advocacy and willingness to stake his political future in bus-based transit is what distinguishes Houston from many areas.

Houston's willingness to take risks also bodes favorably for the future. Plans call for continued experimentation with non-traditional services, like cross-town express runs. METRO has begun retrofitting HOV facilities with new on-off ramps to provide direct connections to subcenters, like Uptown/Galleria. It is also the only regional transit agency today actively experimenting with Advanced Vehicle Control Systems (AVCS). Using machine vision and forward-looking radar sensors, METRO hopes to one day laterally and longitudinally guide buses on and off of HOV lanes.[19] Biarticulated buses that serve transit centers and park-and-ride lots would also operate more efficiently and safely with on-board guidance systems. METRO officials hope that one day buses will operate automatically along HOV lanes before heading off to other destinations. Close spacing of buses would allow the carrying capacity of HOV lanes to increase dramatically. An automated highway system would also allow buses to run in both directions on the HOV lane, potentially doubling the capacity of the current uni-directional facility.

Besides automated guidance systems, METRO is also exploring real-time rideshare matching between the western end of the Katy Freeway corridor and the Uptown Galleria subcenter. A demonstration program is under way to see if instantaneous matching of people seeking carpool passengers and those seeking carpool rides is feasible, both technologically and financially. The demonstration also includes real-time information on traffic conditions and bus schedules.[20] METRO is also pioneering the application of Digiplan, a touch-sensitive electronic map that allows customers to touch their origins and destination on display screens, and are then given bus routes, schedules, and directions on how to use the bus in four different languages. If new-age technologies are to find useful applications in the transit field, odds are that Houston will be one of the first places to introduce them.

2.6 Lessons from Houston

In greater Houston, transit aims to serve development rather than shape it. By improving the quality of services to low-density, auto-reliant areas, of course, transit has unavoidably reinforced growth patterns. However, this is the Houston way, and to the credit of civic leaders, an appropriate role has been defined for transit that is in accord with residents' lifestyle preferences.

Houston's transit operator, METRO, has been exemplary in identifying markets and targeting appropriate services tailored to those markets. More often than not, this has resulted in non-traditional transit service offerings, including tangential and circumferential routes, local-express service integration, activity-center circulators, and various forms of shuttle services. The combination of small-vehicle feeders and express buses operating on HOV lanes – most linked at transit centers and park-and-ride lots – has produced a classic hub-and-spoke transit network. Transit services within some suburban centers, most notably the Texas Medical Center, have been as intensive as anywhere in the United States. Transit's market share at TMC is likewise well above the national average for edge cities. Services to suburban centers should materially improve when METRO completes the construction of fly-over ramps from HOV lanes to the centers themselves. The jury is still largely out on Houston's efforts to mount functional and cost-effective forms of Adaptive Transit services. Recent progress has been promising, and no one can dispute that Houston is doing as well as any American city in matching transit services to settlement and trip-making patterns.

Notes

1. Federal Highway Administration, *Journey-to-Work Trends in the United States and Its Major Metropolitan Areas, 1960-1990* (Washington, D C.: Federal Highway Administration, U S Department of Transportation, 1994)

2. R Dunphy, Transportation and Development in Houston: Beyond Edge City, *Moving Beyond Gridlock: Traffic and Development*. (Washington, D.C.. Urban Land Institute, 1997, pp 143-156).

3 *Ibid*

4 Significant shares of these monies have been diverted to road improvements in recent times, mainly under the logic that smoother flowing roads also benefit buses.

5. R Cervero, *America's Suburban Centers: The Land Use-Transportation Link* (Boston. Unwin-Hyman, 1989).

6 The five freeway corridors currently served by HOV lanes are Gulf (Interstate-45), Southwest (U.S. Route 59); North (Interstate-45); Katy (Interstate-10); and Northwest (U.S. Route 290). Carpools of two or more occupants are allowed on all HOV lanes, except the Katy Freeway, which requires 3 or more occupants during rush hours. During the first decade of HOVs, only buses and vanpools were allowed. Complaints that lanes were underutilized prompted the opening of the lanes to carpools in 1990. HOV lanes are free. A High-Occupancy Toll (HOT) experiment which allows 1 or 2 occupant vehicles on the Katy Freeway facility during rush hours for a fee is currently under way.

7. METRO's park-and-ride lots have spaces for over 27,000 vehicles and are designed as safe, attractive places for transit riders and carpoolers to leave their cars Park-and-ride lots are fenced, landscaped, and have on-site security. Parking is free, however, commuter bus riders pay substantially more for services than do users of local bus services.

8 D. Christiansen and D Morris, *An Evaluation of the Houston High Occupancy Vehicle Lane System* (Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation, 1991).

9. J. Sedlak, *Lessons Learned in the Development of Houston's HOV System* (Houston: Metropolitan Transit Authority of Harris County, 1995)

10. *Ibid.*

11 R. Henk, D. Morris, and D. Christiansen, *An Evvaluation of High-Occupancy Vehicle Lanes in Texas* (College Station: Texas Transportation Institute, Texas A&M University, 1994.

12. M Rossetti and B. Eversole, *Journey to Work Trends in the United States and Its Major Metropolitan Areas: 1960-1990* (Washington, D.C. U S. Department of Transportation, Federal Highway Administration, 1993).

13 Metropolitan Transit Authority of Harris County, *1990 Origin and Destination Study* (Houston: Metropolitan Transit Authority of Harris County, 1991).

14 Urbitran Associates, Inc., et al., *op cit.,* 1997.

15 In 1996, parking at the TMC cost $70 per month for a garage space, $55 per month for a surface lot, and $40 per month at service lots.

16. The $10 subsidy is offered if an employer provides a guaranteed ride-home program or if the employer provides a start-up subsidy for new vanpools METRO will offer a dollar-for-dollar match, up to $35 per month per rider, if an employer matches the subsidy.

17 *Ibid.*

18 R. Cervero, *op cit ,* 1997.

19. Vision-based technologies are also being experimented with Under this approach, a video camera is mounted inside the front window to monitor road conditions The video signals are proceeded by an on-board computer to keep the bus in the lane and on the road. Steering is controlled through a steering actuator assembly, which consists of an electric motor and gearhead which drives the steering column Longitudinal control of the bus, structured around a collision warning system, is achieved by controlling the throttle and brakes to maintain a required speed A safe following distance from the traffic ahead is maintained by using input from a radar sensor mounted above the front bumper Source. Metro News, Houston Buses Ride Automated HOV lane, *Metro*, Vol. 93, No 5, 1997, p 20.

20 G. Murry, D Koffman, and C Chambers, *Strategies to Assist Local Transportation Agencies in Becoming Mobility Managers*, Washington, D.C., Transportation Research Board, 1997.

Chapter Three

Busways and Seamless Transferring: Ottawa, Canada

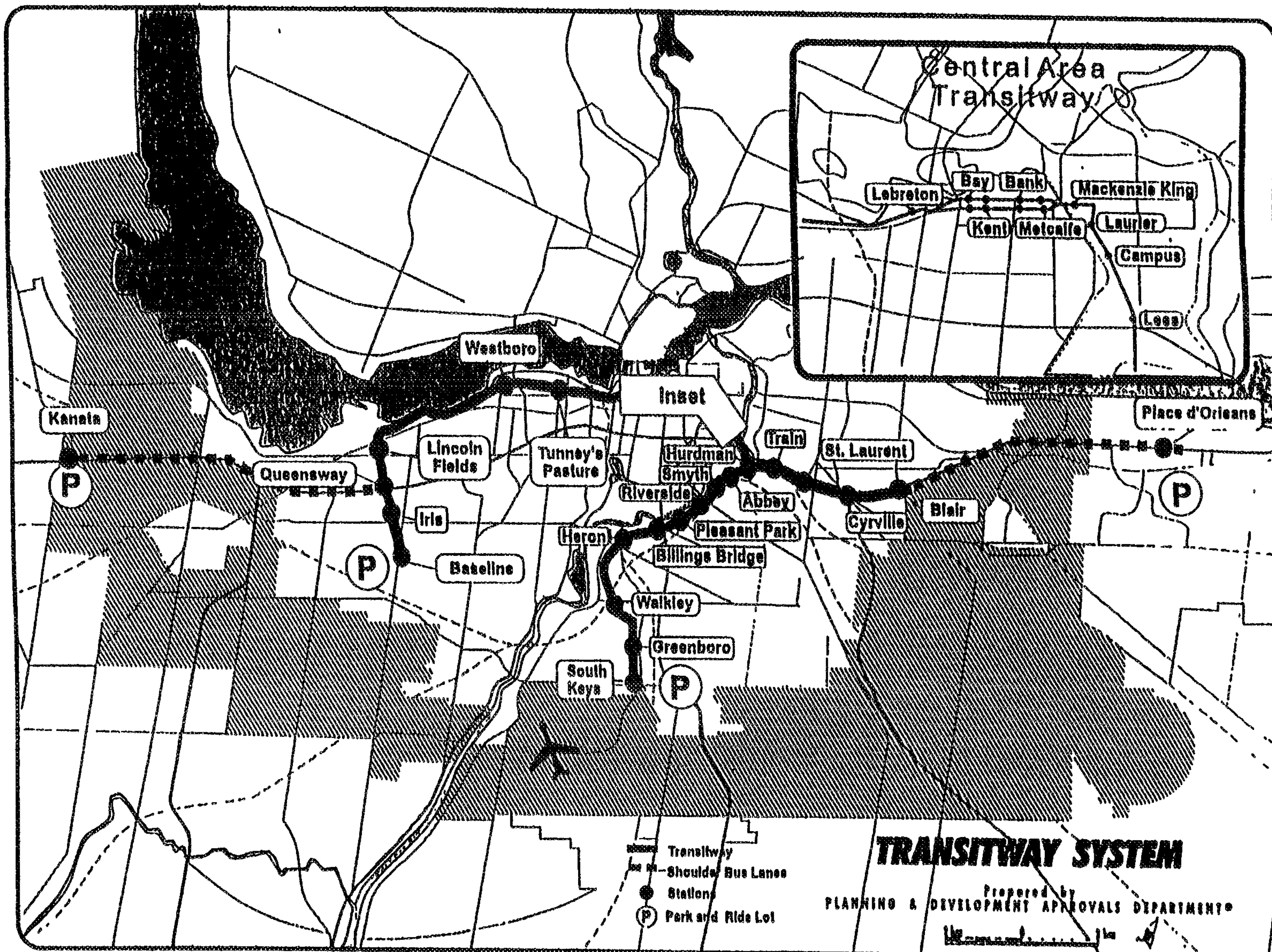
3.1 Synopsis

Thanks to far-sighted planning, metropolitan Ottawa today boasts a highly functional bus-based transit system well-suited to the region's mixed settlement pattern – a compact center and spread-out suburbs. Using a dedicated busway, Ottawa has achieved many of the advantages of a rail-based rapid transit system, with an added bonus – vehicles can leave and return to the guideway, thus reducing the need to transfer. A bus-based rapid transit system also provides flexibility advantages, like the ability to open the system in stages. Today, Ottawa's bus-only guideway connects more than 200,000 daily passengers to the region's urban centers Nearly three-quarters of all peak-hour trips headed to downtown Ottawa are by transit. Transit's share of trips to suburban shopping and employment centers is as high as that to the downtowns of many similar-size North American regions. The most important service feature of the busway has been its ability to accommodate express bus and limited-stop routes that provide passengers with a direct, no-transfer ride between their homes and places of work. Today, virtually all major employment centers in the region can be reached with no more than one transfer between express routes, whether they are on the busway or not. And contrary to conventional wisdom, greater Ottawa shows that busways can attract high-rise development, including condominium towers.

3.2 The Ottawa-Carleton Region

Greater Ottawa, Canada, physical landscape has sharp contrast. The core area is quite compact for a metropolis of 720,000 residents. Outside the core, however, one finds classic suburbia, not unlike many medium-size Canadian and U.S. metropolises. A notable difference, however, is the presence of a greenbelt, formed in 1959, that collars the city of Ottawa and its early post-war suburbs. The protective greenbelt has proven its value over time as an instrument for creating a built form conducive to transit riding – in Ottawa's case, aboard buses that are well-adapted to the mixed high-rise/low-rise lay of the land. As development has leapfrogged across the greenbelt in recent times – concentrating mostly around two outlying town centers – a flexible bus-based transit system has demonstrated itself to be the appropriate technology for the region.

The centerpiece of the region's transit system is a grade-separated right-of-way reserved just for buses – what locals call a Transitway. Map 3.1 shows the region's 31-km Transitway, the largest bus-only guideway in North America, in addition to the greenbelt that rings the city of Ottawa and its post-war suburbs. The Transitway plays a dual role: it both funnels buses into the built-up core and, since buses can leave the guideway, provides an efficient conduit for transfer-free connections to the spread-out suburbs.



Source: Regional Municipality of Ottawa-Carleton, Planning & Development Approvals Department, 1997.

Map 3.1. Metropolitan Ottawa's Transitway and Greenbelt

3.2.1 Growth and the Economy

Ottawa, Canada's capital, with a population of some 300,000 residents, is one of 11 municipalities that make up the Regional Municipality of Ottawa-Carleton (RMOC).[1] Situated south of the Ottawa River in northeastern Ontario, RMOC 's jurisdiction extends far into the rural countryside. Over 90 percent of the region's 720,000 inhabitants, however, live inside the greenbelt. During the 1980s, RMOC's population grew at an annual rate of 2.1 percent, faster than any urban area in Canada. Much of this growth occurred in and around newly designated urban centers outside the greenbelt, principally Kanata to the west and Orléans to the east (see Map 3.1).[2]

Downtown Ottawa (represented by the inset in Map 3.1) contains one-quarter of the region's labor force and around half of all federal jobs. As throughout North America, jobs are rapidly suburbanizing, however – a fact that has not gone unnoticed by the RMOC in its long-range planning.

3.2.2 Institutional Structure

Essential to successfully linking transportation and land use in Ottawa-Carleton has been regional planning and governance. The RMOC is the upper level of a two-tier municipal government structure. Created by the Province of Ontario and modeled after Metropolitan Toronto, the regional government was formed in 1969 to carry out comprehensive planning, invest in major infrastructure, and provide regional services within a geographic spread almost four times the size of Metro Toronto.[3] RMOC's elected members serve on the Regional Council, whose responsibilities include overseeing regional transit services and planning for future development.[4] The Regional Council appoints members within their own ranks to the Ottawa-Carleton Regional Transit Commission, or OC Transpo, the region's transit operating authority.[5]

Local governments, which make up the second tier of the regional structure, perform primarily local functions, like waste collection and fire services. They also regulate land use through zoning laws and subdivision approvals While the Regional Council wields approval and veto powers over municipal zoning and subdivision actions, in practice it rarely overrules the wishes of a municipality barring any egregious conflicts with the region's Official Plan.

3.3 Creating a Transit Metropolis

3.3.1 The Official Plan

Crucial to creating a metropolis with viable transit services has been the Official Plan. This document sets overall regional development policies, determines the types and locations of major permitted land uses, and identifies regional infrastructure investments that are necessary to support land-use objectives. Plan development and approval is a shared responsibility of RMOC and the 11 local municipalities.[6]

3.3.2 Regional Development Strategy

As with all good plans, the Regional Council first established a vision of the future. Based on broad-based citizens input, in 1974 the Council endorsed a multi-centered urban structure: downtown Ottawa would retain its position as the dominant commercial, employment, and cultural center of the region, and would be orbited by a hierarchy of primary and secondary urban centers. Outside these centers, market-driven (predominantly low-density) patterns of development would be largely permitted.

The chief instrument for achieving this physical form would be the Transitway. With a vision in place and the agreement to build a busway to make the vision a reality, the Regional Council turned its attention to land-use management. This led to the adoption of transit-oriented development policies that called for substantial increases in the share of regional jobs located near Transitway stations The long-term goal is for 40 percent of the region's jobs to be within walking distance (400 m) of the Transitway. (In 1996, the figure was about 32 percent.) This means that over the next two decades, more than half of all new jobs created in the region are to be near Transitway stations. The two principle suburban catchments for job growth, the Orléans and Kanata urban centers, are slated for over 10,000 new jobs.[7] The Official Plan also requires regional shopping centers of over 375,000 square feet (34,840 m^2) gross leasable space be sited near the Transitway or future extensions.[8]

3.3.3 Transportation Strategy

Complementing the Official Plan's Regional Development Strategy is a Transportation Strategy that sets targets for transportation investments and gives specificity to the Transitway concept.

Transit First Policy

Over the past two decades, an overriding objective of the Official Plan has been to rely on public transit to provide much of the additional transportation capacity needed to accommodate future growth. The 1974 Official Plan embraced a "transit first" philosophy: improvements to the existing transit system and the development of rapid transit should take precedence over all forms of road construction and widening. The regional plan specifically called for creating rapid transit services. No commitments were made on preferred routing or transit technologies.

The region's "transit first" policy has paid off handsomely. From 1975 to 1986, approximately one-third of the growth in total trips and virtually all of the increase in trips to downtown Ottawa were absorbed by the transit system.[9] During the same time, few improvements were made to the road network serving the central area. In fact, in 1986 fewer automobiles left the central area in the evening peak hour than in 1975.

The Transitway

The Transitway has been the cornerstone of the Regional Council's strategy to promote transit riding and multi-centered growth. The idea of a Transitway surfaced in the early 1970s as both a tool to guide growth and a response to the mobility needs of a rapidly growing population. Ottawa-Carleton opted for a busway at a time when every other medium-size North American metropolis investing in new transit systems selected the eminently more popular light rail transit (LRT) technology. Similar in size to Ottawa-Carleton, Calgary and Edmonton both constructed regional light rail systems in the 1970s and 1980s, while Vancouver, the nation's third largest metropolis, built an elevated "advanced" light rail system called SkyTrain. The decision to go with a busway made Ottawa-Carleton region a maverick of sorts, but in dollars and cents made perfectly good sense. Relative to the light rail alternative, busways were shown to be 30 percent cheaper to build and 20 percent cheaper to operate [10] Because of the busway's relatively high operating speeds, the region has been able to get by with 150 fewer buses than would have otherwise been needed to carry the same number of passengers on surface streets. These savings exceeded the $275 million capital outlay for the first 20 kilometers of the busway.[11]

Today, Ottawa-Carleton averages more riders per capita than any similar sized transit system in North America, including those with rail. In 1991, its 133 unlinked transit trips per capita was nearly double the 69 transit trips per capita recorded in Calgary and Edmonton, the two rail-served Canadian cities of similar size.[12] Ottawa-Carleton has spent less than half as much as these two cities on rapid transit, yet enjoys almost double the ridership.[13] In 1994, around 200,000 people used Ottawa-Carleton's Transitway each day compared to the approximately 100,000 daily riders on the Calgary and Vancouver rail systems, and even fewer on Edmonton's. And while peak-period transit ridership decreased across Canada in the 1980s, it grew by 10 percent in Ottawa-Carleton. On a passenger per guideway mile basis, Ottawa's busway outperforms all other North American busway and light rail systems built over the past two decades by nearly four to one (Figure 3.1).

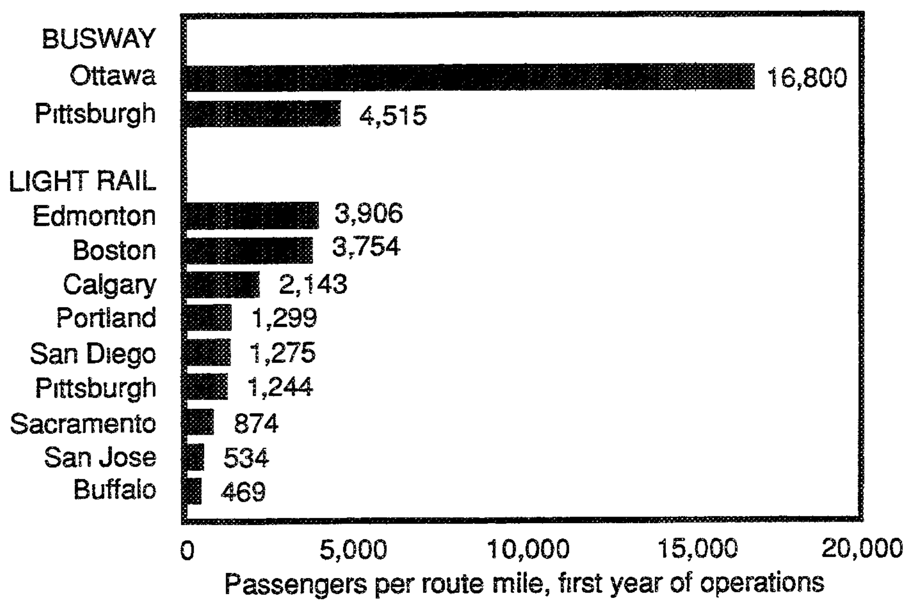
An important advantage of the region's busways has been their staging flexibility; sections can be immediately put into service when completed, regardless if they are connected to the rest of the system. This has allowed the busway to provide prompt relief to congestion hot-spots and to exploit land development opportunities as they avail themselves. Also, the region chose a novel "outside-in" approach in building the system. Rather than constructing the more expensive downtown sections first, the Regional Council instead concentrated on first getting some of the outlying segments of the busway installed. This allowed more kilometers of exclusive busway to be built faster with available funding – which proved valuable in establishing momentum and gaining political credibility. It also allowed completed sections to be put into operation while other sections were being built. Moreover, it meant that transit could influence the development of the region to a much greater extent than had the inner lines serving the already built-out urban core been constructed first. It was fortuitous that Ottawa-Carleton was the fastest growing urban area in Canada during the height of busway construction; as a result, outlying busway segments were in a position to channel the growth that was underway. Today, per capita peak period transit usage in Ottawa-Carleton is as high in suburban areas, where the Transitway first opened, as in the older established parts of the city.[14]

The Eventual System

In 1988, the Regional Council updated its Official Plan to extend the Transitway to the inner edge of the greenbelt. As growth leapfrogs over the greenbelt, the Regional Council is looking to the Transitway to ensure that it occurs in a concentrated form. Presently, dedicated freeway shoulder lanes are used along the busway to connect to the emerging urban of Orléans and Kanata; because the freeway section along the greenbelt has no on/off ramps, buses can operate along the shoulder lanes without interruption. Plans call for eventually extending the Transitway itself to the Orléans and Kanata urban centers and possibly beyond, creating a strong east-west growth axis and extending its reach to some 70 kilometers total.

3.3.5 Supportive Parking Policies

Complementing transit-supportive design initiatives have been policies aimed at restraining parking. When the Transitway opened in 1983, the federal government began eliminating free parking for its employees and reducing downtown parking supplies. By 1984, downtown parking was 15 percent below the 1975 inventory, despite a near doubling of office space. The federal government also introduced flexible working schedules for its employees, producing a more even distribution of transit usage over the course of the day.



Sources. American Public Transit Association (APTA), *Transit Fact Book* (Washington, D C : APTA, 1991, 1992, and 1993); data provided by the Canadian Urban Transit Association (CUTA)

Figure 3.1. Comparison of Passengers per Guideway Mile Among North American Busway and Light Rail Systems, 1991 to 1993

Supportive parking policies have also been introduced at Transitway stations themselves. As shown in Map 3.1, OC Transpo has restricted park-and-ride facilities to the Transitway's terminuses to encourage the use of feeder and expresses as well as to maximize the development potential of selected stations.[15] Additionally, several municipalities have introduced transit-supportive parking policies of their own. The City of Ottawa, for example, allows a reduction of 25 parking stalls for every bus stall provided at retail centers (whether in the form of an on-site bus stop or a stall outside a Transitway station that is physically integrated with the retail center).

3.4 OC Transpo: Adapting Transit to the Cityscape

The 'proof in the pudding' that coordinated transit and urban development matters is found in the world-class bus system that today serves the Ottawa-Carleton region and its impressive ridership statistics. This section examines how bus services have been adapted to the region's settlement pattern, and the resulting payoff.

Today, the regional transit carrier, OC Transpo, schedules a peak fleet of 800 buses that provide some 2.1 million hours of annual service. This fleet moves more passengers per day than any other comparable-size system in North America – on average, around 320,000 riders, including some 200,000 on the Transitway.

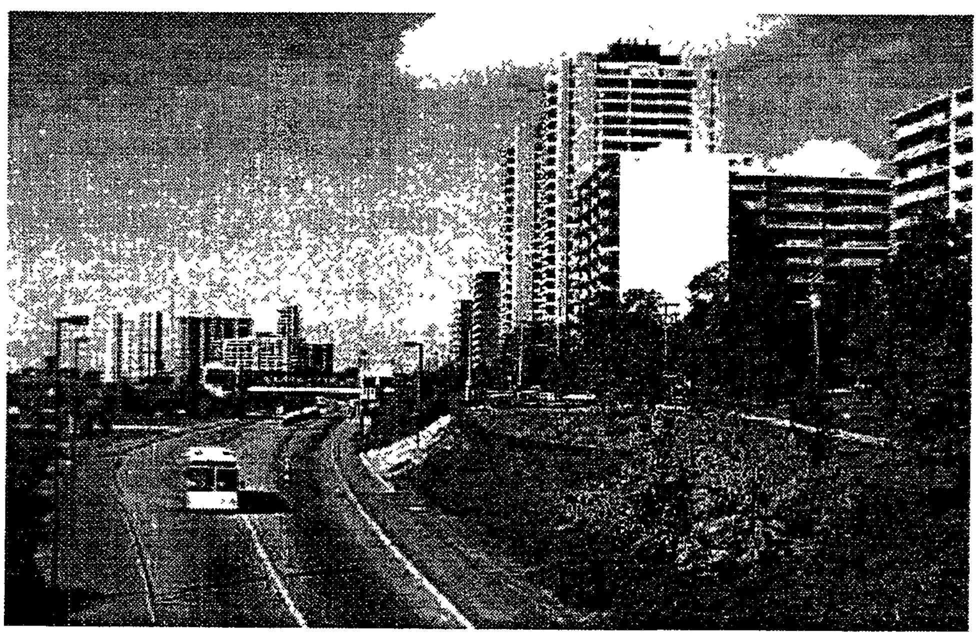


Photo 3.1. OC Transpo's Exclusive Busway. A bus heads westbound from the Smyth station, which features high-rise housing and office development on one side. One station down in the background is the Abbey station where additional high-rise housing has clustered

3.4.1 Today's Transitway

In 1996, the 31 kilometers of dedicated Transitway first called for in the Official Plan were completed at a cost of around US$400 million. The system consists of three components: 25.8 km of exclusive busway lanes – set in an open cut, grade-separated from the surrounding road system, with ramp access provided at key locations (Photo 3.1); 2 km of downtown bus-only lanes; and 3.3 km of mixed-traffic operations along the Ottawa River Parkway. Supplementing this system are the 10.6 kilometers of reserved freeway shoulder lanes within the greenbelt that serve the Orléans and Kanata urban centers. Presently, the Transitway can be accessed at any one of 34 stations or six downtown bus stops. The two beyond-the-greenbelt stations – Orléans and Kanata – have been sited in the heart of the planned urban centers *in advance* of extending the Transitway itself.[16]

The Transitway today functions as the backbone of regional transit services. On a per-kilometer basis, it carries ten times as many person trips as the regional road system.[17] Around 60 percent of all transit rides in the region include a significant component of Transitway service. At peak load points, nearly 10,000 passengers per hour are carried on the Transitway. To carry this many trips by automobile would require five freeway lanes per direction.

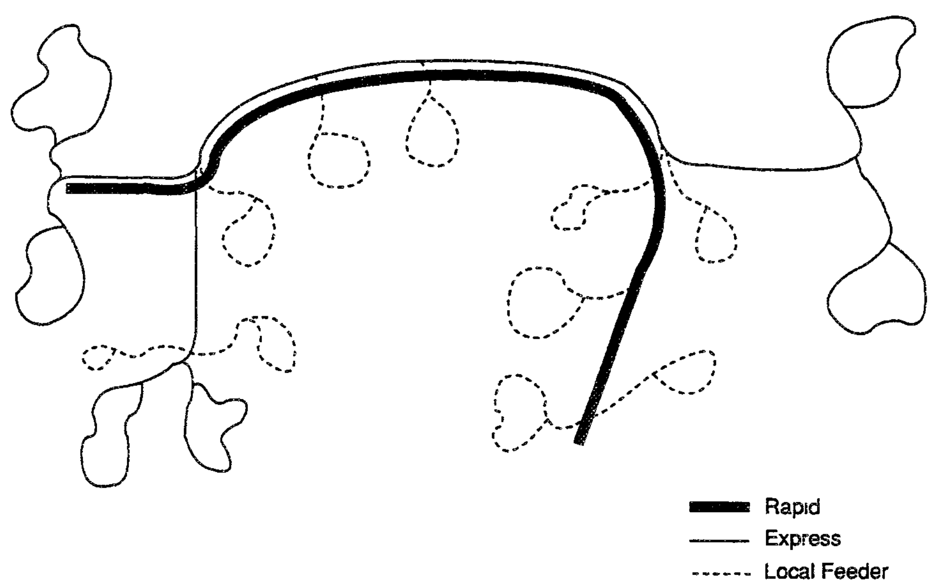
Ottawa's Transitway operates just like an urban rail system. Buses stop at all stations (which are spaced around a half kilometer apart in the central area and several kilometers apart elsewhere). The two-lane (13-meter-wide) facility has passing lanes at stations so that buses can overtake each other. Platforms are up to 55 meters long to accommodate as many as three buses. Stations look and function like those of a subway system; all are equipped with elevators, are weather-protected, and have seats and schedule information. Some are connected to surrounding areas by pedestrian skywalks. The geometries and overhead clearances of the Transitway were designed to allow an eventual conversion to fixed-rail transit if and when demand warrants such a change.

When passing through downtown, buses operate on a one-way couplet along Albert and Slater Streets. The second lane, rather than the curb lane, is dedicated to buses. This avoids conflicts with stopped and parked vehicles. Also at downtown stops, sidewalks have been widened into the curb lane to provide more waiting space for passengers. Presently, downtown stops accommodate over 30 different bus routes during peak hours and handle up to 25,000 boardings and alightings each day. Over 60 percent of regional transit traffic passes through the Albert-Slater Street couplet. Because of these high loads and with passenger throughput approaching the capacity of a surface transit system, OC Transpo is studying the feasibility of operating downtown segments in a subway alignment.[18]

3.4.2 Configuring Bus Services

What has proven to be the right "match" to Ottawa-Carleton's lay of the land is a hub-and-spoke transit network. However, unlike a rail-based hub-and-spoke system, the Transitway allows an integration of mainline and feeder services in a single vehicle. The same vehicle that whisks along the dedicated right-of-way can leave the facility and filter into the region's spread-out neighborhoods, thus eliminating the need to transfer.

In all, three complementary types of services operate along or feed into the Transitway (Figure 3.2). The "Rapid" lines (three routes numbered in the 90 series) operate solely along the exclusive guideway, with buses coming by every 3 minutes and stopping at each station. True to their billing, they are swift, averaging speeds in the 45 to 60 km per hour range, even taking into account stops and peak bus loads that are 15 to 20 percent higher than those of regular surface-street buses. High average speeds are possible because of the better schedule adherence afforded by busway operations and barrier-free (honor) fare collection, along with the use of multiple door loadings at stations.[19] Signal prioritization at key traffic lights expedite bus movements along downtown streets.



Source OC Transpo *Transitway Programme* (Ottawa OC Transpo, 1994).

Figure 3.2 OC Transpo's Three Types of Transit Routes

Supplementing the Rapid lines are Express routes that connect residential neighborhoods and employment centers during peak hours. Express buses run on 8 to 20 minute headways, sometimes in a skip-stop mode.[20] To serve outlying employment centers, OC Transpo also operates counter-peak, or reverse commute, services. It is the express and reverse-commute bus runs that largely eliminate transfers. The same bus that picks people up near their residence also deliver them near their destinations via the Transitway. The elimination of transfers has made Express services hugely popular – presently they account for the majority of OC Transpo patronage. Express services are an adaption of transit to settlement pattern *par excellence.* In Ottawa-Carleton, it is accepted that low-density living environments are preferred by most residents, and that transit programs should in no way seek to alter this settlement pattern, but rather to serve it. While high-rise commercial development is actively sought around Transitway stations, it is totally left to the marketplace to dictate where and at what densities housing gets built.

During off-peak hours, services convert to timed-transfer operations. Under this arrangement, the Transitway functions exclusively as a trunkline – the three Rapid routes continue running, though on slightly longer, 5-minute headways. Local feeder bus routes fan into surrounding neighborhoods, connected to Transitway stations, in synch, on 30-minute pulse schedules. Park-and-ride lots at terminal stations function as intercept points for rural catchments, serving passengers living beyond the region's urban areas.

An important part of OC Transpo's infrastructure is its fully automated telephone passenger information system. All stations and stops in OC Transpo's service area have been assigned a telephone number with a 560 prefix. Customers can dial and find out, for a particular stop, when the next two buses are scheduled to arrive, as well as route status information, such as unexpected delays – a valuable service in a place where sub-freezing winter temperatures are the norm.[21] Similar information is also displayed on large video displays at major transit terminals and shopping malls – a real convenience to those who would rather spend five or so minutes before a bus arrives window shopping than waiting.

Each month, OC Transpo responds to more than 850,000 inquiries on the automated telephone system, primarily during the off-peak when headways are longest. The information system enjoys high visibility – one survey found 82 percent of regional households knew about it, and 26 percent used it on a regular basis. Also, the system has increased OC Transpo's off-peak patronage by an estimated 8 percent, based on a controlled statistical comparison of ridership changes in neighborhoods with and without access to the information service.[22]

3.4.3 The Payoff

Modal Splits

The superb adaptation of OC Transpo services to the settlement pattern is reflected by ridership statistics. OC Transpo currently serves around 35 percent of all peak-hour vehicle trips originating in the urbanized area. Moreover, it handles around 70 percent of peak-period work trips to downtown (coming mostly from low-density suburbs) and nearly 30 percent of trips generated by suburban employment sites near the busway. Even regional shopping centers designed for the automobile, but on the busway, enjoy all-day transit modal splits for shop trips in the 25 to 30 percent range.[23] At suburban job centers and retail plazas off the Transitway, transit modal splits fall in the 5-10 percent range. The region's high suburban transit modal splits are a testament to the fast, efficient, minimal-transfer features of the busway.[24]

Development Impacts

The Ottawa-Carleton region has seen considerable land-use changes around Transitway stations. In keeping with the Official Plan, several hundred thousand square meters of office and commercial floorspace have been added within a five-minute walk of suburban stations, with Blair and Place d'Orléans as notable standouts. Regional shopping malls, like St. Laurent and Gloucester Centre, have also been physically linked to the Transitway. And while not called for in the Official Plan, stations like Westboro, Tunney's Pasture, and Hurdman have seen nearby mid-rise apartment and condominium development in recent years.

During the boom years of 1988 to 1991, local officials estimate that a billion Canadian dollars of development was added or at various stages of completion within a five-minute walk of the Transitway. This was nearly four times the 275 million Canadian dollars spent on the 20 kilometers of Transitway that were in place at the time. While the Transitway itself did not induce anywhere near this amount of investment, it unquestionably had a strong bearing on where new office, retail, and residential construction took place within the region.

It should be noted that it was never intended that land around all stations be intensified. Western sections of the Transitway were built on open parkland owned by the National Capital Commission with no potential for development Other stations, like Iris and Lincoln Fields, were placed in locations where physical site constraints and the presence of established single-family neighborhoods preclude any significant new development from ever occurring.

3.5 Lessons

Ottawa-Carleton demonstrates the rewards of smartly adapting transit to serve the lay of the land. While its busway is well suited to serving low-density development, at the same time, thanks to conscientious regional planning, it has been a powerful lever in guiding employment and commercial growth. In Ottawa-Carleton, policymakers have understood and taken advantage of the two-way interaction between urban form and transportation investments.

Today, there is near universal agreement that a bus-based Transitway system was the right technological choice for Ottawa-Carleton. It provides a high level of service to the predominantly low-density residences of the region, while also providing a focus for channeling future employment and commercial growth. Remarks Colin Leech, head of OC Transpo's long range planning section:

> One of the major advantages of a busway compared to an LRT system is that it gives the benefits of a fixed infrastructure without the drawbacks of a fixed guideway. The presence of a fixed rapid transit infrastructure gives developers and the public the confidence that a high level of service will always be provided to the stations, so that stations can act as a catalyst for promoting transit-friendly patterns of development. The lack of fixed guideway allows incredible flexibility of operations. The new Transitway station at Place d'Orléans is a prime example of how a busway station will be able to influence growth decades before a separate right-of-way is built to it.[25]

The foundation for Ottawa-Carleton's world-class bus network was established during the 1970s with the passage of an Official Plan, and strengthened in subsequent updates. The Transitway was enlisted as the chief instrument for achieving a multi-centered built form. As a result of far-sighted public policies, today Ottawa-Carleton boasts numerous examples of mid-rise office, commercial, and residential development near Transitway stations. This tradition continues. In coming years, the Transitway will be used as a magnet for concentrating beyond-the-greenbelt development.

It is important to note that the Regional Council first established a regional land-use vision, and then developed a transportation strategy to achieve that vision. The Official Plan accepts that most residents prefer to live in low-density residential settings and does not attempt to alter these preferences. The transportation "means" to support this land-use "end" was the introduction of a highly flexible, integrated bus transit network. Buses fan into surrounding neighborhoods, and provide either direct express services or feed into nearby Transitway stations on a timed-transfer basis. In contrast to most U.S. rapid transit systems, park-and-ride has been discouraged as an access means to Transitway stations. This not only reduces parking lot expenses and frees land for commercial-office uses, but also yields environmental benefits by eliminating short-hop (high-polluting) automobile access trips to stations.

Currently, the region is engaged in a debate over whether to continue emphasizing a radial transit system focused on downtown – specifically, whether scarce dollars should go to improve downtown busway circulation by constructing tunnels or instead be used to extend the Transitway to new town centers. This debate turns on the question of whether downtown Ottawa will retain its dominance as the region's employment hub, or whether the pace of decentralization will accelerate. True to Ottawa-Carleton's tradition, land-use objectives can be expected to guide which of these two transit investment strategies the region pursues over the next decade.

Notes

1. The region encompasses the Cities of Ottawa, Gloucester, Kanata, Nepean, and Vanier, the Townships of Cumberland, Goulbourn, Osgoode, Rideau, and West Carleton, and the Village of Rockcliffe Park

2 These areas have captured about 80 percent of new construction of single-family homes and townhouses built in the region Between 1986 and 1994, more than twice as many people were added to urban centers outside the greenbelt as inside it, almost doubling their populations.

3. RMOC was created, through an Act of the Ontario government, in direct response to rapid suburbanization and growth overspilling the boundaries of the City of Ottawa Comprehensive planning within an area large enough to encompass the region's commutershed was considered essential. While there was some local support for regional planning, it only occurred because it was a legislatively imposed requirement of the Provincial government.

4. Other responsibilities of regional government include water distribution, wastewater treatment, solid waste disposal, region roads, social and health services, and maintaining homes for the aged.

5. OC Transpo is a separate corporate body run by a nine-member Commission which reports to the Regional Council OC Transpo serves a designated Urban Transit Area which in 1990 had a population of 586,000 and included the Cities of Ottawa, Gloucester, Kanata, Nepean, and Vanier, the Township of Cumberland, and the Village of Rockcliffe Park.

6. All development within the region takes place within the framework of the Official Plan, but amendments to the plan are made from time to time based on requests from developers or local municipalities. Implications of proposed changes are examined thoroughly before they are approved

7. The seven other designated PECs are Baseline, Tunney's Pasture, Vanier, St Laurent, Cyrville, Blair, and South Keys.

8 The only exception is the Carlingwood shopping complex, which for historical and geographic reasons is being accepted as a retail destination that will be reached predominantly by private automobile.

9 Regional Municipality of Ottawa-Carleton. *Community Profile* (Ottawa. RMOC, Planning & Property Department, Report 6-12, 1994).

10 Part of the operating cost savings is attributable to the region's ambitious interlining of buses – 40 percent of all vehicles make a trip on one route and then deadhead to the start of a revenue-collecting section of another route rather than returning to the original route's start. This scheduling practice, which shaved Ottawa-Carleton's peak fleet requirement by 12 percent in the mid-1980s, could not be exploited with a rail system.

11. J. Bonsall, *Rapid Transit for the Automobile Age* (Ottawa: OC Transpo, 1993).

12 Hit by recession, ridership has fallen to around 110 annual transit trips per resident. Ottawa-Carleton, however, has weathered the recession as well as any Canadian urbanized area, and with the exception of Vancouver its relative loss of transit customers has been less than in other areas See OC Transpo, *Operating Statistics* (Ottawa· OC Transpo, 1996); and J. Pucher, J., Public Transport Developments Canada vs The United States, *Transportation Quarterly*, Vol. 48, No 1, 1994, pp. 65-78

13. J. Bonsall and R. Stacey, *A Rapid Transit Strategy into the Next Century* (Ottawa: OC Transpo, 1994)

14. *Ibid.*

15. There are currently 1550 parking spaces· 515 at the Place d'Orléans station (eastern terminus), 460 at Kanata, 300 at Greenboro (one station in from the South Keys terminus station on the recently opened south line); and 275 at Baseline (terminus of the southwest line)

16 The Regional Council hopes these stations will act as magnets for concentrated, mixed-use development. The Place d'Orléans station, serving the surrounding bedroom residential community of Orléans (approximately 50,000 inhabitants), lies in the heart of an evolving urban center that includes an indoor shopping mall and the Cumberland township's new civic center. A similar process of transit-led development is presently under way in Kanata and is being considered for a possible third beyond-the-greenbelt urban center to the south, Barrhaven.

17. Bonsall and Stacey, *op cit.*, 1994.

18 The downtown couplet can theoretically handle up to 200 buses per lane per hour under ideal operating conditions. Scheduled bus volumes are today approaching 200 buses per hour Incidents of total system failure with downtown travel times of 45 minutes or more on cross streets now occur once every two to three months.

19 J. Bonsall., *op cit.*, 1993.

20. Under skip-stop operations, buses skip certain stations and only stops when there is a waiting customer at one of these stops who hails the vehicle for a ride.

21 Electronic signpost strategically placed throughout the region monitor bus movements, relaying real-time information to a centralized computer which in turn passes schedule adherence information, through digital voice transmissions, to customers who phone in

22. Sources: R Cervero, Urban Transit in Canada: Integration and Innovation at Its Best, *Transportation Quarterly*, Vol 40, No. 2, 1986, pp 293-316, J Bonsall, and M. Whelan, Better Information Equals More Riders Paper presented at the annual meeting of the Canadian Urban Transit Association, Quebec City, Quebec, June 1981.

23 The main sources for these estimates are the 1986 Retail Survey and the 1986 National Capital Area Origin-Destination Survey, both conducted by RMOC. The 1986 survey found the following transit modal splits for shopping centres that are currently served by the Transitway (or dedicated freeway lanes connected to the busway): Rideau Centre – 61 percent; Billings Bridge – 22 percent, Carlingwood – 21 percent; St. Laurent – 16 percent; Bayshore – 13 percent; and Place D'Orléans – 9 percent At the time of the survey, however, the Transitway did not extend to Billings Bridge, St. Laurent, or Place D'Orléans Transit modal splits have significantly increased to all of these shopping centers over the past decade. For instance, 1993 figures released by the management of the St. Laurent shopping centre showed a transit modal split of 32 percent

24 These modal split achievements are also partly attributable to stringent standards set in the Official Plan. The plan sets targets for peak-hour transit modal shares at screenlines along all major travel corridors Targets are used in setting priorities among competing road and transit projects along each corridor. Currently, targets call for transit to attain a market share of 70 percent of trips to downtown, 40-45 percent for destinations near Transitway stations in the central area, and 30 to 35 percent for trips generated by development near suburban stations and on the outer limits of the system To date, the downtown targets have been reached and considerable headway has been made in achieving the others.

25 Personal correspondence, dated April 24, 1995.

Chapter Four

Bus Rapid Transit on Surface Streets: Quebéc Province, Canada

4.1 Synopsis

North America's undisputed leader in the development of low-cost forms of Bus Rapid Transit has been the eastern Canadian province of Québec. In Québec City and Montréal, regular surface-street lanes have been reassigned to bus transit in an all-out campaign to create rubber-tire services that begin to match some of the operating features and speed advantages of underground metros, but at a much cheaper price tag. An overarching philosophy in both cities has been to give priority to transit, through lane dedication as well as signal prioritization. Along mainline corridors, distances between bus stops have been lengthened so as to achieve high average speeds, creating something akin to skip-stop services. Lots of care and attention went into revamping services, section-by-section, in the quest for new riders and productivity gains. Absent a public largesse, both cities needed to radically break away from past entrenched practices, but in an economical and politically acceptable way. Energetic marketing has proven vital in building a base of public support for Québec province's own unique form of high-quality bus services.

4.2 Bus Rapid Transit in Québec Province

Canada's Québec province lays claim to two of the first Bus Rapid Transit (BRT) programs introduced anywhere Québec City, the provincial capital with a regional population of around a half million, has during the 1990s developed a series of mainline bus services operating on dedicated lanes along major thoroughfares that are swift and time-competitive with the private car, especially during commute hours. Montréal, the province's largest metropolis with a population of 2.3 million, has turned to a combination of contra-flow and with-flow bus lanes to provide speedy, line-haul services in major corridors unserved by its underground metro. In both cities, sophisticated signal systems and full-service transfer centers have also been vital in expediting bus flows on surface streets. Buses in Québec City and Montréal operate faster than light-rail trains in other Canadian cities that share regular street-space. Bus rapid transit services have been introduced – however, at a fraction of the cost that would have been incurred in constructing capital-intensive fixed-guideway improvements.

Québc's leadership role in developing bus rapid transit in North America might have something to do with Francophile influences. France has made more headway in innovating new forms of rubber-tire transit than anywhere, beginning with Paris's pneumatic-wheel metro (later mimicked by Montréal) and a 300-km network of bus lanes on Parisian streets, complemented more recently by the construction of a 170-km network of exclusive busways in the suburbs of Paris.

4.3 Québec City

During the 1980s, Québec City suffered the fate of virtually all North American cities: steadily eroding transit ridership. From a height of 44 million annual riders in 1984, by 1990 yearly patronage had fallen below 40 million. With a newly elected board, the region's transit agency, Société de transport de la Communauté urbaine de Québec (SCTUQ), realized that some soul-searching was in order. The board eventually came to the conclusion that past practices of attempting to serve everyone and all trips with uniform, one-size-fits-all services was doomed to failure. A paradigm shift of sorts was called for. SCTUQ's new philosophy would be to target services at customers for which it could reasonably compete with the private automobile (Table 4.1). Its services would be customized and judiciously designed. Rather than trying to be all things to everyone, the agency would instead focus on satisfying the bonafide travel needs of potential transit patrons. The overriding aim would be to coax motorists traveling along main corridors out of their cars during peak hours. From surveys and focus groups, it was found that the greatest ridership gains would accrue from persons under the age of 25. This meant penetrating new markets and winning over a different class of "choice" customers, for population was growing the most among those at the middle stages of the lifecycle. Clearly, a new direction was called for.

Table 4.1. SCTUQ's New Philosophy on Transit Services

	Main Constituency	Market Orientation	Service Design
The Past	Everyone	All Trips	Uniform
The Future	Patrons	Peak & choice riders	Targetted at niches

4.3.1 Reconfiguring Services

In June 1992, Québec introduced a package of service reforms that produced a unique, low-cost form of bus rapid transit (BRT) (see Box 4.1). Good data and careful analyses of what customers wanted formed the key inputs for revamping services. Notably, an unusually large 15 percent sample of regional motorized trips provided detailed origin-destination data for both 1991 and 1996.[1] What stood out from the survey was a clear many-to-few pattern of trip-making: that is, many-origins to few-destinations. The presence of distinct travel flows between sectors of the city, some of which were tangential in orientation, spoke to the need for high-performance bus-based transit along existing road rights-of-way.

The decision was made to site new high-performance services in the most densely populated areas so as to interconnect key activity centers and provide near door-to-door services. There would be a central axis from downtown to the burgeoning commercial center of Ste. Foye to the southwest, forming the backbone of the network. Complementing the central axis would be a line north of downtown to Charlesbourg and one from downtown to Beauport to the east. This meant services would lie within a quarter-mile walking distance of 80 percent of employment generators within the region.[2] From the 1996 survey, it was also found that 45 percent of all motorized trips during the morning peak occurred along these three corridors. If bus transit was to succeed in Québec, these corridors would need to be intensively served.

Box 4 1

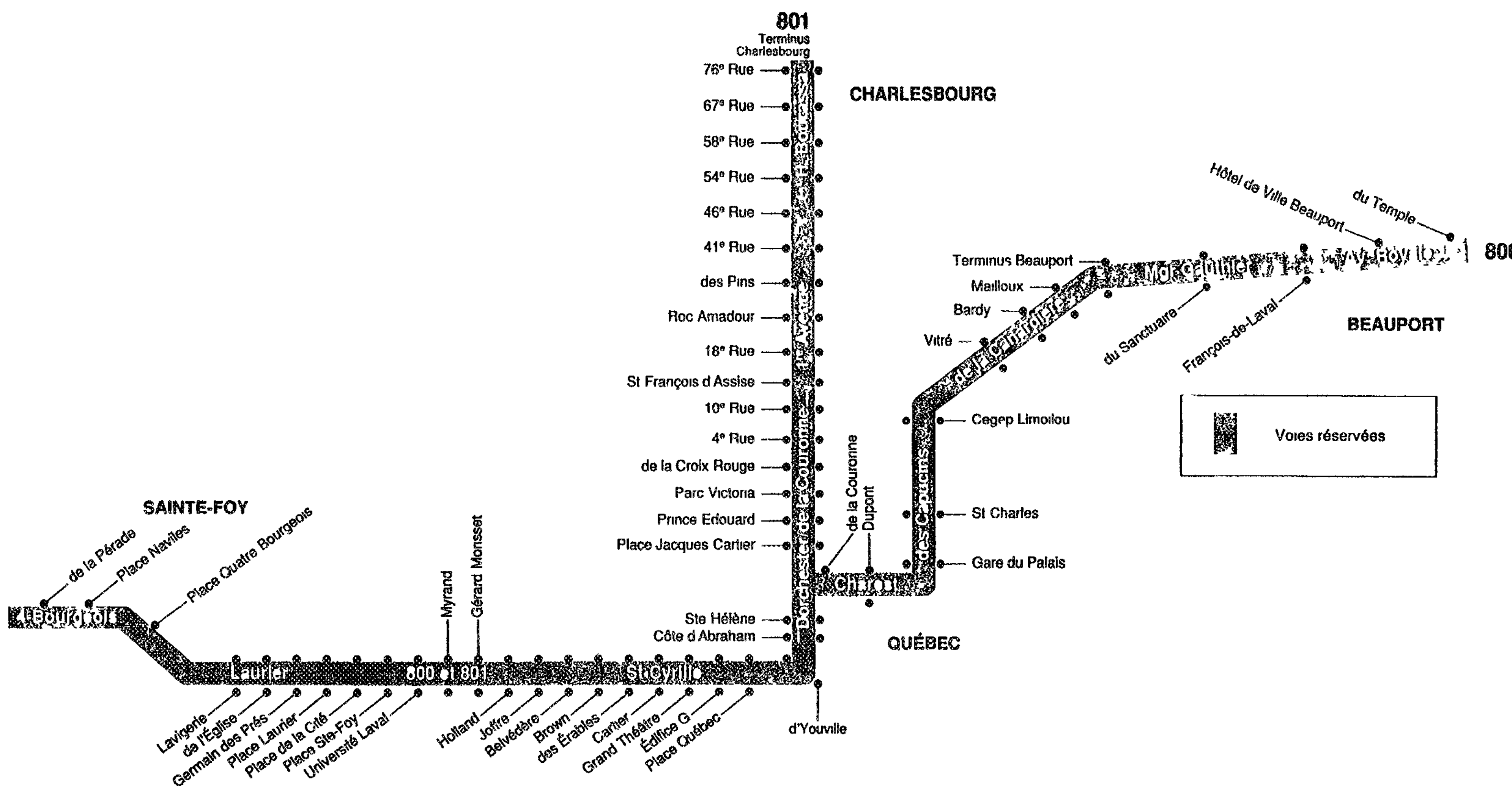
Key Features of Québec's Bus Rapid Transit System:
Metrobus

- Reserved lanes
- Frequent, reliable, high-volume service
- Signal prioritization
- Lengthening of bus-stop spacings
- Transit centers/terminals
- Numerous, scattered park-and-ride lots
- Passenger information systems
- Distinctive appearance

The challenge at hand was to produce services that matched the quality of an underground metro, but which, given Québec's comparatively small population and antiquity, by necessity operated along existing surface streets. The fact that lines would penetrate the most populated areas meant that new grade-separated facilities would be unacceptably disruptive and prohibitively expensive. Accordingly, the decision was made to expropriate and dedicate 35 kms of existing curbspace along the three main travel axes to buses, forming a low-cost version of exclusive right-of-way services (see Map 4.1).[3] The typical reserved lane would be 10 to 12 feet wide, and would lie on both sides of a street, providing a with-flow system of reserved-lane services.[4] Transit planners were able to convince local politicians that this would maximize "people" as opposed to "car" throughput, at the objection of local traffic engineers and the police chief.[5] Their argument was simple but effective. If transit carried 30 percent of people heading downtown, then it should get 30 percent of road capacity.[6]

As if to underscore the *rapid* transit characteristics of new services, buses operating along these corridors were christened "Metrobuses". This also meant that service intensities had to match those of Montreal's metro (the point of reference of most Québec residents with regard to rail rapid transit) Peak-hour headways on Metrobus routes were more than cut in half, from 5 minutes to 1 to 2 minutes. Some off-peak headways also fell from 10 minutes to 2 to 4 minutes.[7] To save on costs, not all off-peak services go to the terminuses of the Metrobus lines. And some off-peak services were eliminated altogether, in recognition that transit cannot compete with the car for many shopping and discretionary trips. Off-peak cuts were in keeping with the desire to judiciously reallocate services to best accommodate the mobility needs of peak-hour customers. This meant sacrificing some off-peak services in order to support more intensive peak services. From a ridership standpoint, this meant targeting services to the most elastic (choice) market at the expense of less elastic (and often more captive) off-peak markets.

Functionally, Québec's Metrobuses serve as line-haul carriers, providing swift services for large volumes along main travel axes (Photo 4.1). Formally, Metrobuses operate as Route numbers 800 and 801, constituting two of SCTUQ's 93 total routes.[8]



Map 4.1. Québec's Three Major Metrobus Corridors

Photo 4.1. An Elephant Train of Metrobuses Along a Collector Street on the St.-Cryille Corridor

In addition to dedicating curbside space, high average speeds along Metrobus routes have been achieved by cutting the number of bus stops in half Metrobus stops lie on average 1,300 feet, or a quarter mile, apart. Continual stopping and going not only discourages ridership, but can also take its toll on the longevity of buses themselves. Because buses come by more frequently, SCTUQ has discovered that patrons are willing to walk farther to reach a stop. Also expediting bus flows has been the introduction of a bus priority scheme. To reduce conflicts and delays, buses turning left from right-side curbside lanes have their own signal phase, preempting all other phases.

4.3.2 Facilitating Transfers and Connections

In addition to fast, frequent services, SCTUQ planners were mindful of the need to reduce the incidence of transferring by providing direct mainline services. Where transferring is necessary, the process is facilitated through carefully designed real-time connections. Providing feeder connections are what are called "express buses", which were more than doubled in number during the late 1980s, from 18 to 40. Circuitous routes were eliminated and some routes were realigned to provide more direct services Respectable headways of 15 minutes or less have been maintained on all feeder routes, even on Sundays.

Important to facilitating transfers has been the creation of major transfer centers. These are the loci for coordinating crosstown journeys in which a trip origin, destination, or both lie beyond walking distance of a Metrobus route. Transfer centers vary considerably in size and scope. The busiest center, or what SCTUQ calls a terminus, is downtown (Terminus d'Youville), where 800 buses pass through every weekday (Photo 4.2). Outside the CBD, the system's major time-transfer point is Les Saules, which actually lies off of a Metrobus corridor, situated in an established residential neighborhood (Photo 4.3). In all, 27 buses converge on the Les Saules center, like clockwork, on 15-minute peak and 30-minute off-peak headways some 16 hours a day. Another substantial transfer point is found at Laval University, where a 800-foot-long loading zone connects to surrounding campus buildings via an underground tunnel, which is heavily utilized in the winter. The facility was jointly developed – SCTUQ paid for the construction, and the University maintains it in addition to having donated the land upon which it sits.

SCTUQ planners also recognized that many customers heading downtown or to a major center would prefer to drive to main-line bus stops. Thus, as with any metrorail service, there was a recognized need for suitable park-and-ride facilities. In all, 25 neighborhood park-and-ride lots have been built, some on public property (like schoolyards) and some on private property (e.g., shopping centers which benefit from proximity to transit customers) at no costs to SCTUQ. All are small, between 10 and 40 spaces per lot. Focus groups revealed customers prefer small lots because they minimize walk access time and instill a greater sense of security. Also, by scattering more small-size lots throughout the region, car-access distances to transit lines were shortened [9] As a result, the typical car access trip to a transit line today only takes 2 and a half minutes.

SCTUQ planners view bus-to-bus transferring as inherently superior as bus-to-rail inter-connections. In contrast to underground metros, the Metrobus allows same-level transferring. Walking up and down flights of stairs is perceived as onerous among transit users in bigger cities like Montréal. Indeed, having buses always at street-level is viewed by SCTUQ as an effective marketing device, prominently showcasing the "product", Metrobus, to transit users and non-users alike.

The sum product of the past decade of bus rapid transit development in greater Québec has been the creation of a highly efficient hub-and-spoke network (Map 4.2). Collectively, six major terminuses provide transfer points that tie into the three mainline bus routes operating along dedicated lanes as well as to other major express routes.

4.3.3 Supportive Policies

As is often the case, successful transit reforms in Québec City also relied on "getting the prices right". This mainly took the form of mandatory parking charges downtown, which in 1998 averaged US$50 per month. Importantly, this amount exceeded the cost of a monthly bus pass (US$38). Effective marketing of new services was considered crucial. Metrobus services were distinguished from other buses by a green color scheme. Both buses and the lanes they operate along were painted green. Moreover, each bus stop is called a "station", sporting a special number and Metrobus logo. Marketing campaigns continue to highlight Metrobus as a unique, distinctive service. Indeed, SCTUQ's ad-men are quick to note that "customers don't take transit; rather, they take *Metrobus*".

4.3.4 Impacts

Québec's stylized form of BRT has yielded positive results. The number of passengers per express bus trip increased from 37 three months prior to service reforms to 39 three months after.[10]

Photo 4.2. Québec's Downtown Transfer Station

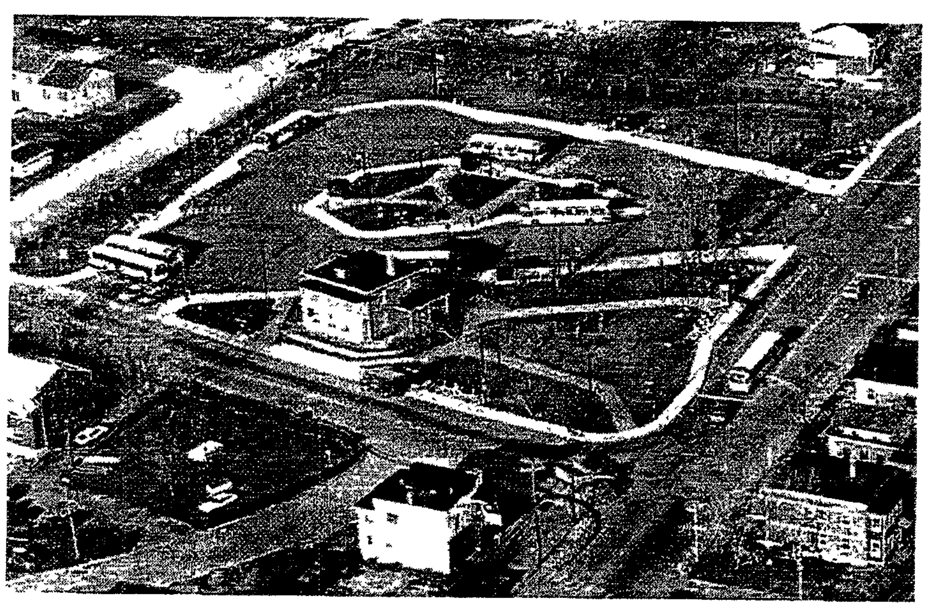
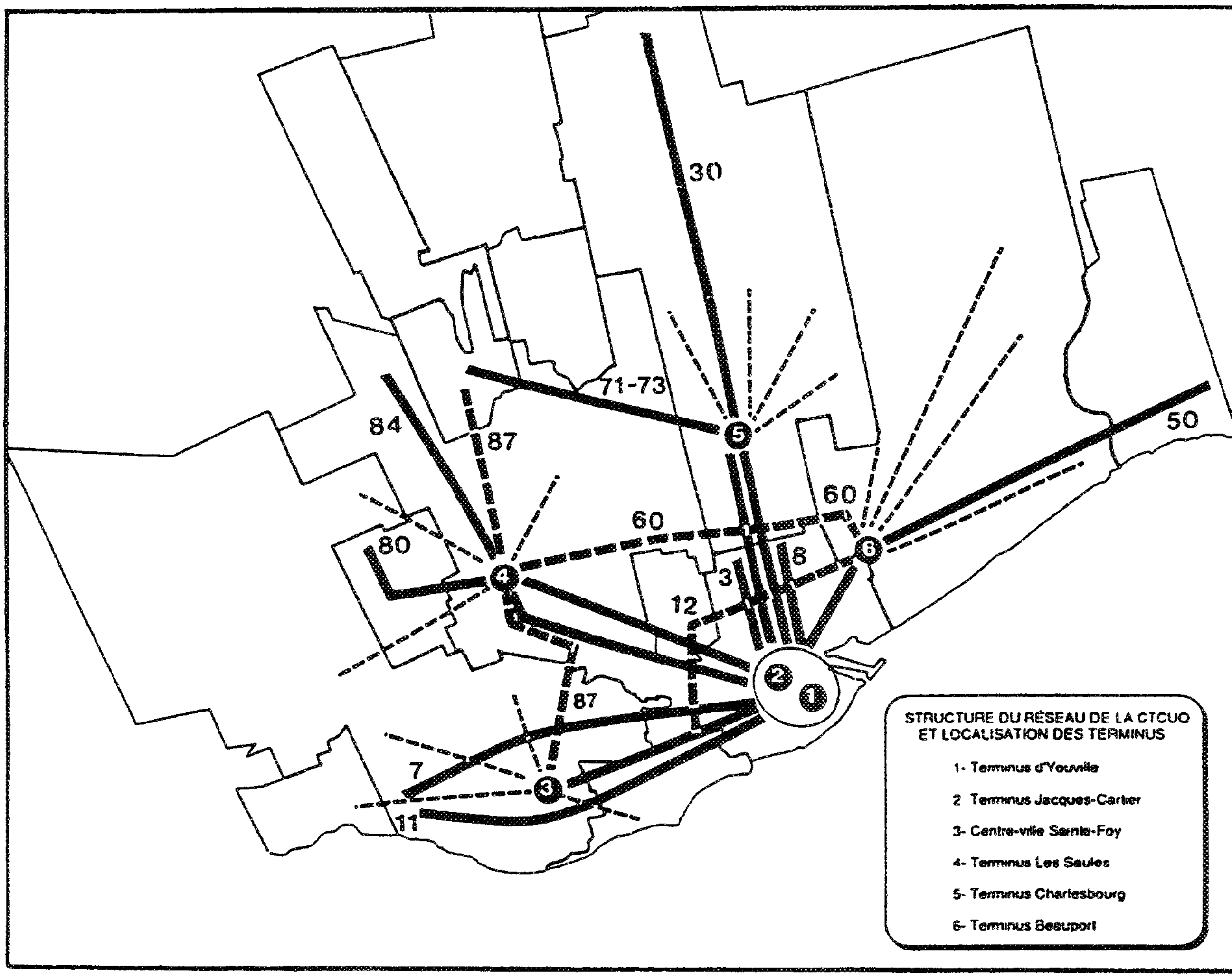


Photo 4.3. Les Saules Transit Center



Map 4.2. SCTUQ's Hub-and-Spoke Network

While not a huge increase, this represented a reversal of trends which up to that time had been decidedly downward.

Metrobus services operating along dedicated lanes have been the most successful. In 1998, Metrobuses averaged 75 passenger trips per revenue hour (compared to a systemwide average of 37). Metrobus ridership rose steadily from 1992 until 1994, when a three-month driver's strike brought all but peak-hour services to a halt.[11] In the past few years, ridership has begun to regain its earlier stature. In the minds of some, Metrobus has almost been "too" successful. Indeed, the number one complaint SCTUQ receive from customers is the over-crowded conditions of Metrobus during peak periods.

SCTUQ's success at aligning services to match dominant origin-destination patterns is attested by the fact that 85 percent of transit trips in greater Québec involve no transfer. Services go "where the action is". This has not been without a cost, however. It meant shifting resources to

Metrobus and express buses, while cutting back on local bus services. However, SCTUQ's objective of luring motorists out of their car has been largely achieved. In 1993, one year after introducing service innovations, surveys revealed that 53 percent of Metrobus riders could have traveled by car. Also, 15 percent of Metrobus peak-hour patrons were new riders who previously solo-commuted. Surveys further showed that 37.3 percent of patrons got to work in less time via Metrobus than by car, and 46.1 percent said journey-to-work times by Metrobus and personal automobile were comparable.

4.4 Montréal

An even more extensive network of dedicated bus lanes has taken form during the 1990s in Québec province's largest metropolis, Montréal. Between 1989 and 1994, 37.3 km of reserved bus lanes were built (Map 4.3). Operated by STCUM (Société de transport de la Communauté urbaine de Montréal) within the municipality of Montreal, these dedicated bus lanes serve areas bypassed by Montréal's subway, and also function as feeder connectors to metro stations.[12]

Among the network of reserved bus lanes are 8.6 km of contra-flow lanes: 6.7 km in the city of Montréal and another 1.9 km in Montréal-Nord. Called R-Bus ("R" for reserved lane), the contra-flow lanes were built in lieu of a proposed subway extension for just US$4.5 million (in 1996 dollars). While the Metro functions as the city's mobility backbone, R-Buses serve as an important bus-based complement.

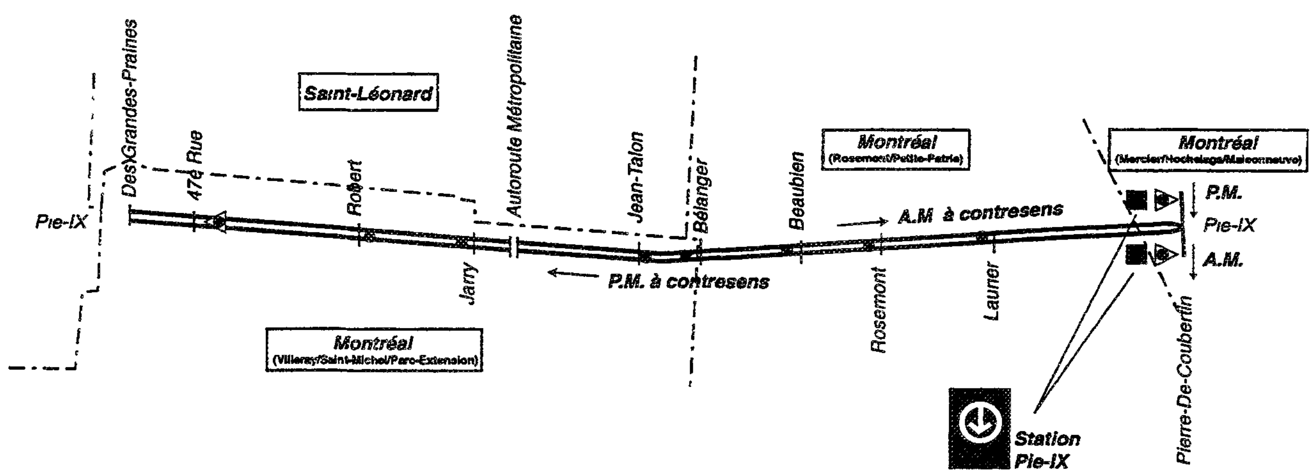
4.4.1 Contraflow Lane Service

The crown jewel of Montréal's BRT network is the system of counter-, or reverse-, flow lanes. Montréal's main contra-flow lane operates along Boulevard Pie-IX, a wide six-lane arterial that runs in a north-south direction. Situated to the east of downtown Montréal, the boulevard connects the municipality of Laval to the north with the Pie-IX station on Line 1 of the Montréal Metro, which is also the station that serves the Olympic Stadium.

Boulevard Pie-IX is a fairly straight facility, which operationally helped in setting up the reverse-flow system (Map 4.4) The directness of service allows for a less-interrupted ride and also reduces disruption of traffic making right turns on or off the boulevard. In the morning, from 6 to 10 a.m., one of Pie-IX's outbound lanes is converted to an inbound lane, allowing buses heading south to operate in the northbound lane nearest the median. STCUM took advantage of directional imbalances in traffic flows in designing the R-Bus service, which is formally Route 505. R-Buses operate on headways of 2½ to 5 minutes. Each R-Bus carries a large, flashing yellow arrow below its windshield warning of its approach.

The logistics of the R-Bus service are fairly straightforward. At each intersection, orange traffic cones are used to separate the inside lane from the rest of traffic. In the afternoon, the process is repeated, reversing directions. Evening departures from the Pie-IX metro station are timed around the arrival of metro trains. Overhead lights with large illuminated red Xs indicate the contra-flow lane is in service and motorist must stay out of the way. Lanes have been painted with diamond and signs indicate the hours when use is restricted.

Map 4.3. Montréal's Reserved Lane Network



Map 4.4. Contra-flow Bus Route Along Boulevard Pie-IX, Connecting to Montréal-Nord

Stations lie in the median of Boulevard Pie-IX, which allows counter-flow buses to quickly load and discharge passengers. Stations are made of steel-and-class, giving them protection from the elements. Riders board and alight from buses at shelter doors spaced to coincide with the doors of a 40-foot bus. Stations are closed when contra-flow lanes are inoperative to prevent loitering and vandalism. The combination of exclusive, unobstructed right-of-way and protected station environments has formed a veritable bus-based rapid transit system along the Pie-IX corridor.

Those traveling along Boulevard Pie-IX actually enjoy two travel options. For longer-distance journeys, there is Route 505, which stops every half mile or so, providing something akin to high-speed, skip-stop services. For those going a shorter distance or who want to stop somewhere in between two bus stations, there is a more fine-grained local service option, Route 139, which stops every block or so. Route 139 serves both directions at 5-minute intervals during peak hours. This is in contrast to the Route 505's R-Bus services which operate in only in the peak-flow direction, but on more frequent 3-minute headways. The combination has produced a rich offering of bus-based services.

4.4.2 Advanced Signalization

As in Quebéc City, an important feature of BRT in Montréal is a sophisticated signalization system. Along Boulevard Pie-IX, traffic lights are pre-programmed to accommodate the special turning requirements of contra-flow buses operating in center lanes. To eliminate conflict points and potentially serious accidents, lights ban left turns when an R-Bus is passing through. A signal phase also kicks in that gives an R-Bus priority in turning right across with-flow traffic lanes. All other lights, including those for pedestrian crossings, remain red until an R-Bus has safely completed the turn off of the special lane and onto a regular street.

Traffic signals are coordinated all along Boulevard Pie-IX. Ten sections (each comprising 2 to 4 intersections) are centrally controlled to expedite bus maneuvers. Each R-Bus is equipped with an on-board transponder that through a signpost system allows operators in a central command center to constantly monitor movements. Drivers receive real-time information about how close they are operating to schedule and are advised of upstream traffic conditions. Special signalization and communications systems have proven to be one of the most expensive items in creating the contra-flow lane system. In the case of the Pie-IX line, about 40 percent of the development costs were for signal improvements, poles, special lighting, and computerized communications.

4.4.3 Other Components of BRT in Montréal

Besides counter-flow lanes, Montréal also boasts a large network of with-flow reserve lanes, similar to those found in Québec City. With-flow lanes, which do not require the same degree of segregation and expenditures as contra-flow lanes, operate in the morning and evening peak periods along three main streets: Du Parc, Rene-Lēvesque, and Cote-des-Neijes. Curbside lanes are marked with diamonds and overhead signage (Photo 4.4). During the peak, curbside parking is banned and the lanes are reserved for buses and taxis only. Reversible lanes (controlled by overhead lights) are also used to increase bus throughput along several major arterials in Montréal.

Photo 4.4. Reserved With-Flow Bus Operations in Montréal.
The overhead sign specifies hours of operation.

As in Québec City, buses achieve relatively high average speeds along with-flow lanes because bus stops are spaced far apart, anywhere between 1,200 and 3,400 feet from each other. Another important component of high-quality bus services has been the introduction of low-floor buses. SCTUM has begun replacing conventional buses with low-floor coaches not only to expedite passenger boardings and alightings but also to give the city's bus system a more modern, premium-quality image.

4.4.4 Impacts

Contra-flow lanes have been an unqualified success in Montréal. Today, R-Buses average operating speeds of 25 mph (including time spent at stops and boarding customers), compared to 16 mph for regular buses.[13] Along free-flow stretches, R-Buses achieve speeds of up to 100 kph. Because of these speed advantages, contra-flow lanes offer an added benefit – they provide an unobstructed lane for ambulances and other emergency vehicles. Travel time savings have been important; however, surveys reveal that what is valued even more is improved reliability. R-Buses adhere to schedules 99 percent of the time, compared to an 85 percent on-time performance for regular buses.[14]

While service outputs have improved, more importantly so have service outcomes, namely ridership. During the first year of operation, R-Bus ridership increased by about 35 percent.[15] With-flow services have also proved productive. Routes that converted to reserved with-flow operations experienced, on average, a 10 percent increase in ridership within one year (adjusting for systemwide ridership trends).

An unexpected benefit of dedicated-lane services has been safer driving among motorists. Accidents of all kinds have gone down since R-Bus services were introduced along affected streets. Motorists exercise more caution and drive more vigilantly when directly facing an oncoming bus. A more serious safety problem has been pedestrians who fail to look the opposite direction when crossing the contra-flow bus lanes. Signs at each crosswalk prominently carry warnings, and educational materials on crossing the contra-flow lanes have been distributed to local schools and residences.

4.5 Learning from Québec Province

The Canadian city of Ottawa is well known for its successful dedicated busway, as is Curitiba and other Brazilian cities, however grade-separated bus facilities remain costly investments Québec City and Montréal have opted to reassign street space to buses as a lower cost means of expediting and prioritizing the flow of surface-street buses. The amount of scarce urban space that has been given over to surface buses is substantial, especially in Québec City. In order to put bus transit on equal footing with the private automobile, rewarding transit ridership with fast, efficient services was deemed all-important.

Bus rapid transit requires more than reassigning street capacity, however. Also important has been prioritizing traffic signals in favor of transit flows, coordinating schedules to allow timed-transfers, providing weather-protected transfer stations, and lengthening the distances between bus stops. In combination, these efforts have produced no-frills yet highly cost-effective form of Bus Rapid Transit in Canada's two major French-speaking cities. Absent a lot of capital, Québec policymakers have relied on a number of small, low-cost measures that, in combination, have meaningfully added up.

From the experiences of these two Canadian cities, good marketing is clearly essential to mounting a successful Bus Rapid Transit program. Transit agencies from both cities have consciously portrayed mainline bus services as "metros". They have made an extra effort to convey an image of special services that is a cut above traditional bus operations. Marketing can get people to try an innovation once To retain them, however, requires exceptional services. To date, both Québec City and Montréal have largely provided this.

Notes

1. These were unusually large surveys, capturing 15 percent of all trips on a typical day. Local planners justified the need for larger sample sizes on the grounds that transit historically served only 15 percent of motorized trips.

2. Together, the municipalities of Québec, Ste Foye, Beauport, and Charlesbourg comprise 370,000 inhabitants, or nearly two-thirds of the region's half million population

3. The entire cost of dedicating the 35 km of lane came in under US$400,000. Several million dollars more are currently being spent to upgrade the dedicated facilities by improving overhead lighting and signage. A 1-km stretch of dedicated busway also is found along a freeway segment (in Place de Ville); however, express buses (rather than Metrobuses) operate along this segment. In addition, a special ramp connection to downtown allows express buses to by-pass crowded downtown streets

4. Some sections of Metrobus services in central Québec have no reserved lanes because existing lanes are too narrow and land constraints prevent widening facilities

5. Reserved lanes in old-town Québec and along a 3-km boulevard serving the commercial corridor in Ste Foye operate continuously from 7 a.m. to 5:30 p.m. Elsewhere, the lanes operate only during the peak periods between 7 and 9 a m and between 3:30 and 5:30 p.m.

6. Transit planners were also successful in eliciting the support of the local media by staging public events, continuously releasing studies that supported their positions, and playing up to mounting environmental concerns that were being aired at the time, on the heels of the Rio Summit. According to one SCTUQ planner, during the six months leading up to the board's vote on revamping bus services, transit had become "the talk of the town".

7. Basic services (outside the three main Metrobus corridors) retained former headways of 5 minutes during the peak and 10 minutes in the off-peak.

8. Route 800 operates in an east-west direction, from Beauport to downtown to Ste. Foye Route 801 plies a north to southwest route, connecting Charlesbourg to Ste. Foye via downtown Québec

9 The 1991 regional travel survey showed that the average commute trip by transit was 30 minutes, compared to an average by car of just 15 minutes Providing ample park-and-ride lots to shorten the door-to-door time of taking transit was thus viewed as essential.

10 This represents trips on Metrobus (Routes 800 and 801) as well as express bus runs.

11. Canadian law requires peak-hour services to be retained even in the event of an organized labor strike. All off-peak and express services, however, ceased to operate during the strike period.

12. More than 80 percent of bus lines connect to a metro station.

13. These estimates are based on weighted average comparisons of operations on Route 505 versus Route 139. Source· Société de transport de la Communauté urbaine de Montréaal, *Prolongement de la voie réservée du boulevard Pie-Ix sur le territoire de la municipalité de Montréal-Nord*, Montreal STCUM, December 1997.

14. STCUM considers a bus on schedule if it arrives at a stop anywhere between a minute before and three minues after scheduled arrival.

15. V. Wilkins, R-Bus: A New Concept in Counterflow, *Bus World*, Vol. 13, No 3, 1991, pp 6-7

Chapter Five

Express Shuttles, Coordinated Scheduling, and Small-Vehicle Services: Contra Costa County, California

5.1 Synopsis

Contra Costa County, California, stands out as a rapidly growing suburban setting where the public and private sector have been willing to experiment with new types of transit services, with varying degrees of success. While this case is included in Part One, under "Bus-Based Service Reforms", it easily could have been placed in any of the sections, for Contra Costa County is a case where a variety of suburban transit forms have been introduced, with varying degrees of success. To date, public-private co-sponsorship has been instrumental in launching several highly successful express shuttle services between rail stops and large-scale employment centers. Less successful have been midday shuttles connecting job sites and shopping plazas, a general-public dial-a-ride, and neighborhood circulators. On the other hand, a free shuttle between a rail stop and the suburban downtown of Walnut Creek has reduced local congestion and parking demands, all at the lowest per passenger subsidy in the county. Part of the success with feeder shuttles can be attributable to smart routing – specifically, by interconnecting major activity centers that generate patronage fairly evenly through the day and week. However, a good part can also be explained by factors like efficient intermodal designs (e g., staging areas at rail stops), aggressive marketing, and effective institutional arrangements.

5.2 Adapting Transit to Suburbia: The County Connection

Since 1980, Contra Costa County, California, has grown faster than any other of the six most populous counties in the San Francisco Bay Area. Fueling growth has been affordable housing, comparatively low office rents, an extensive freeway network, and good regional rail access via the Bay Area Rapid Transit (BART) system. With growth, however, has come many urban-like problems, with rising traffic congestion heading the list of public concerns. A 1995 poll revealed that 65 percent of Contra Costa County residents considered traffic congestion to be a "serious" problem. These concerns have from time to time given rise to growth control initiatives, like Walnut Creek's Proposition H, which limited new development as long as critical intersections within the community remained congested (later struck down by the courts as unconstitutional). More recently, the generally politically conservative county has turned to pro-active transportation programs to cope with traffic congestion, with a particular focus on expanded and upgraded bus transit services, provided mainly through its own subregional bus agency.

Over the past decade, Contra Costa has made considerable headway in adapting bus transit to serve its low-density settlement pattern. One of the first steps was the formation of its own transit authority to serve its core cities – the Central Costa County Transit Authority, or CCCTA. Historically, bus services were provided through the Alameda-Contra Costa County Transit Authority (AC Transit), today the 15th largest motor bus system in the country. Because of a local desire to more closely control and to expand bus services, CCCTA was established in 1980. (Subsequently, smaller transit districts have also spun off within the county, such as Tri-Delta Transit in the eastern part of the county.)

Early on, CCCTA recognized that its greatest transit asset was BART, which during its first 22 years of service (1973-1995) had five stations in the county – Concord, Pleasant Hill, Walnut Creek, Lafayette, and Orinda (see Map 5.1). (Subsequently, new stations have opened at North Concord, West Pittsburg/Bay Point, and Antioch.) Over the years, CCCTA has fashioned a "hub-and-spoke" transit service, relying on BART for long-haul, mainline services and its own buses as feeders to BART stations. Thus, BART functions as the county's main transit artery, and CCCTA motor buses are the capillaries. CCCTA christened its feeder bus network "The County Connection", the name that the county's bus services usually goes by.

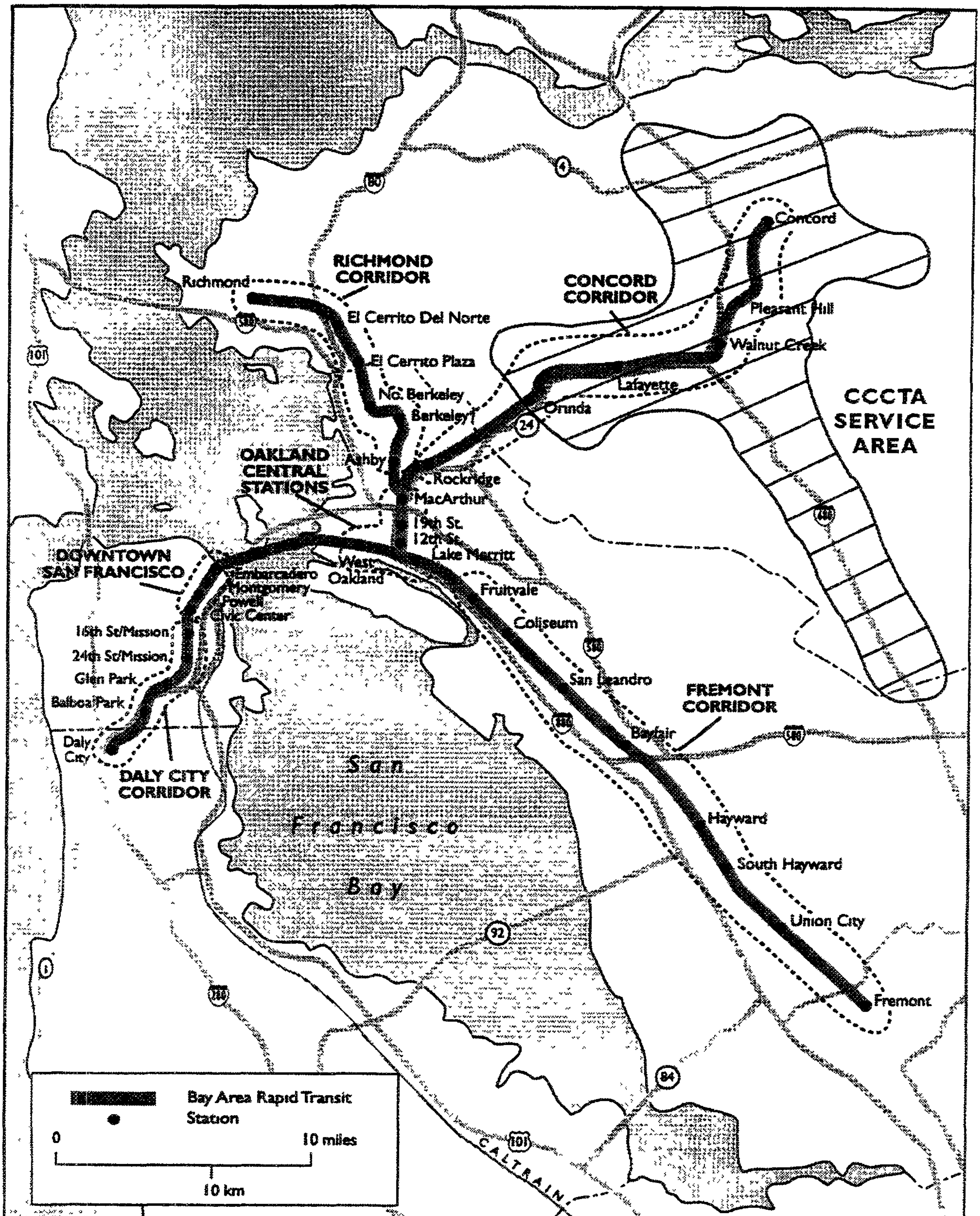
Over the years, CCCTA has also sought to carve out other suburban transit market niches. Many services are noteworthy for their unique institutional arrangements, involving creative public-private partnerships: among these have been shuttle runs to BART involving joint CCCTA/state/municipal funding support; fully municipally supported shuttles, launched by the City of Walnut Creek; and employer-supported express bus operations. In the early 1990s, CCCTA also experimented with general-public dial-a-ride van services. Overall, CCCTA has an exemplary record at service planning. It meticulously monitors and evaluates services on an on-going basis, paring back and expanding bus operations when and where appropriate. Given that the County continues to grow by leaps and bounds, it follows that bus services also need to be dynamic – changing and shifting according to market demand. An excellent service planning program has been put into place to provide for this.

5.3 CCCTA

5.3.1 Existing Services

CCCTA is notable for its variety of services, both past and present. In 1996, CCCTA provided motor bus transit services on 30 routes: 23 conventional bus routes, 4 express commuter routes, and 3 shuttle circulators. In addition, specialized dial-a-ride van services were contracted out in compliance with ADA requirements. Conventional coaches are used on most routes.

All fixed route buses feed into BART stations. Schedules are generally tied to BART's timetables; however, CCCTA does not operate a true timed-transfer, pulse system since inter-modal transfers can be as long as 15 minutes. (As defined in Chapter One, CCCTA's "seamless transferring" is more akin to "coordinated scheduling".) Headways average 40 minutes on weekdays and 60 minutes on Saturdays, with buses running from around 5 a.m. to 9:30 p.m.. As origin-destination trips patterns become increasing complex and many-to-many in the county, CCCTA expects to concentrate more on cross-town, lateral trips in the future. Bus-to-bus transfers have increased by over 5 percent annually over the past two years, whereas bus-to-BART transfers have declined. This reflects the growth in intra-county travel to scattered destinations.



Map 5.1. BART System and CCCTA Service Area

5.3.2 Market Area, Ridership, and Performance

By Bay Area standards, central Contra Costa County is fairly homogenous – largely middle-income, predominantly white households. While historically made up of bedroom communities, central Contra Costa County's land-use composition has become more diverse in recent years. Most notably has been the growth in jobs, from around 65,000 in 1980 to 195,000 in 1995. Regional forecasts call for a 22 percent increase in employment by the year 2005.

Today, CCCTA's serves some 4.3 million (linked) passenger trips each year. This averages to around 10 trips per capita each year for its service area – low by national standards, though typical of all-suburban bus systems in mid- to large-size metropolitan areas.

In fiscal years 1995 and 1996, CCCTA recovered around 22 percent of operating costs through passenger fares.[1] The average operating cost per trip was $2.83. With an average fare of around $0.65 per trip, this resulted in a subsidy of around $2.20 per trip – with a tremendous amount of variation, from a low of $1.11 per trip (for a downtown circulator) to a high of $10.82 per trip (for a neighborhood circulator).

5.4 Suburban-Targeted Services in Contra Costa County

CCCTA operates three main types of services: (1) express bus runs from BART to major employment centers that mainly serve commuter markets; (2) shuttle circulators; and (3) regular fixed-route feeders and cross-town services. This section reviews CCCTA's most innovative and noteworthy attempts at adapting bus transit services to suburban markets – both current successes and past failures.

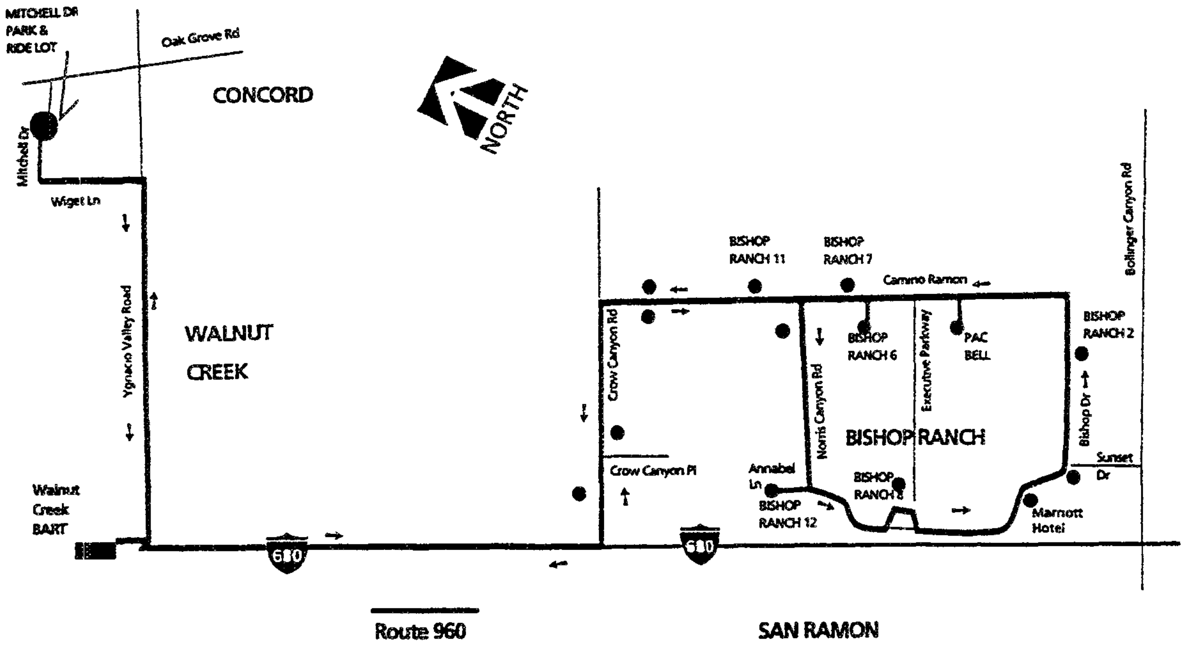
5.4.1. Shuttle Services

Express Shuttles

The express shuttles, which operate between BART and major job centers, are distinguished by their organizational support: (1) public-private co-sponsorship and (2) employer sponsorship.

Public-Private Partnership: Route 960

Contra Costa County offers an example of a creative public-private partnership designed to support suburban rail feeder services. The express shuttle is County Connection Route 960 – a feeder run from the Walnut Creek BART station to Bishop Ranch Business Park (Map 5.2). Bishop Ranch is one of the Bay Area's premier edge cities, a mammoth 585-acre master-planned office-industrial campus, with over 60,000 on-site employees, which fronts Interstate I-680 in the city of San Ramon, a fast-growing suburb about 35 miles east of downtown San Francisco. The Bishop Ranch Business Association historically operated its own express services from BART to the park, contracting for two premium 41-passenger coaches to shuttle tenants' employees between the park and the Walnut Creek BART station; around 4 percent of Bishop Ranch's eligible work



Map 5.2. Route 960 Express Shuttle

force took advantage of the free shuttle connections in the mid-1980s.[2] Because of rising costs and shifting corporate priorities, the shuttles were canceled in 1990 and replaced by Route 960.[3]

It was a unique opportunity for funding assistance that gave rise to Route 960 shuttle service. The opportunity arose when the California Department of Transportation (CalTrans) established a Mitigation Fund as part of a massive, multi-year program to redesign and earthquake retrofit a critical freeway interchange in Contra Costa County – the Interstate 680/Highway 24 junction. The project disrupted traffic flows in the area, so CalTrans established the fund to promote travel alternatives in the corridor. An expanded feeder service to Bishop Ranch was a perfect candidate for funds.

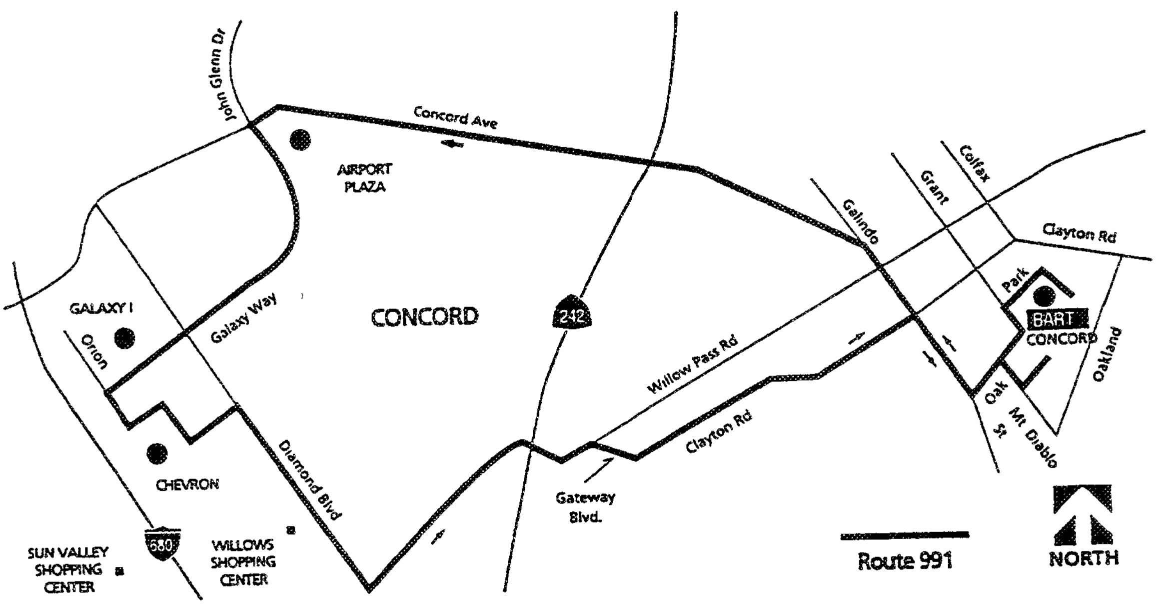
Presently, CalTrans and Sunset Development Corporation (the owner of Bishop Ranch that leases sites to corporate tenants) are jointly subsidizing the 960 Express Shuttle.[4] Bishop Ranch pays $50,000 annually to CCCTA, with CalTrans covering the balance. The jointly sponsored express service has proven to be far more productive than its predecessor. In 1992, Route 960 carried only 6.7 passengers per revenue hour. By 1996, it was averaging more than 16 passengers an hour. Monthly ridership shot up sharply in 1995 – from 2,200 passengers in February to over 7,000 by the end of the year.[5] On some morning runs, there is standing room only, with load factors approaching 1.5. Because of ridership gains, Route 960's operating subsidy per passenger has fallen from $3.47 in fiscal year 1994 to less than $2 today.

The 10-mile journey from the BART Station to Bishop Ranch Business Park takes approximately 25 minutes in rush hour traffic. Employees of Bishop Ranch Business Park ride free by displaying their identification badge to the bus operator, while the general public pays a $1.25 fare. Those arriving via BART pay only $0.50 with a transfer.

Because of trip reduction mandates stipulated under regional air quality rulings, Bishop Ranch is under pressure to reduce auto-commuting among its tenants' employees, and express shuttle services has been embraced as the primary means of compliance. The region's air quality authority has assigned Bishop Ranch a 0.80 target for its Vehicle Employee Ratio (VER) – the number of vehicles used for commuting divided by number of employees.[6] Several years ago, Bishop Ranch's VER was around 0.90, but with the stepped-up Route 960 service, it fell to 0.81 in mid-1995, almost reaching the 0.80 target.[7]

Employer-Sponsored Shuttle: Concord Commuter Express

Subsidized by private employers in Concord for use by their employees, the 991 Concord Commuter Express route stops only at three business parks and the Concord BART station, only during peak hours (Map 5.3). Headways are approximately 30 minutes, and the entire loop takes about 25 minutes. All morning buses, and three out of four evening buses, operate in synch with BART train departures.



Map 5.3. Route 991, Concord Commuter Express

The three business parks that sponsor Route 991 are Chevron U.S.A., Concord Airport Plaza, and Galaxy Office Park Employees ride free by flashing a shuttle card or employee ID; all others pay regular fares. The regular 118 route, which also serves the three business parks and runs during the off-peak, is free to Airport Plaza employees, underwritten by the business park. Chevron U.S.A. agreed to sponsor the express shuttle during negotiations for securing a development permit for the last building on its campus. Initially, Chevron provided its own shuttle service using company-owned vans In 1988, its property manager approached other business parks in the area that were affected by the county's new Transportation Demand Management (TDM) ordinance about jointly subsidizing a County Connection route, with the intention of creating enough critical mass to save money relative to providing separate, in-house shuttles. This led to the creation of Route 991.[8] Average weekday ridership on Route 991 is fairly small, but has increased steadily from 58 in 1993 to over 100 two years later. The operating subsidy per passenger trip is presently around $2.55. By agreement, costs are apportioned among the three business parks under a fair-share arrangement[9]

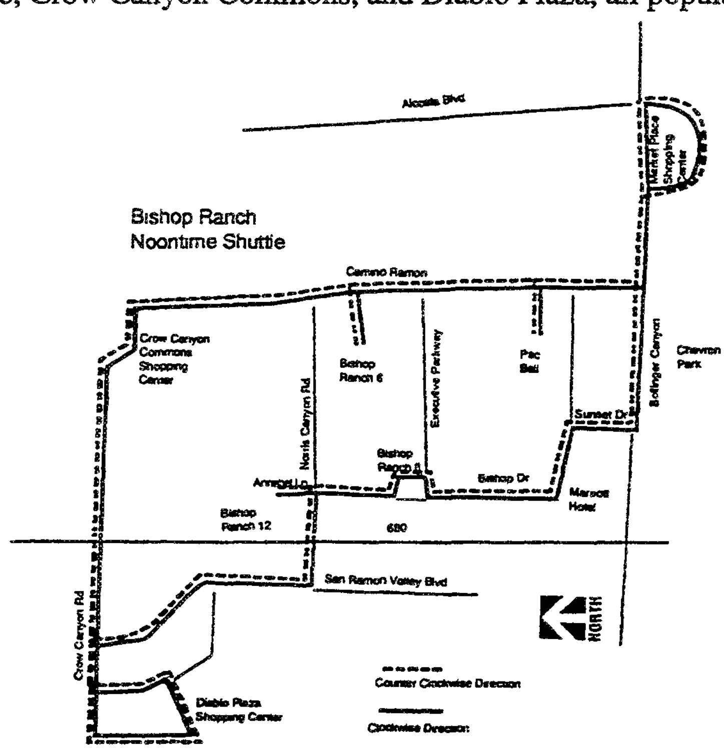
Transportation coordinators for the three business parks are satisfied with Route 991's performance and plan to continue underwriting costs.[10] All three business parks actively market the service to on-site employees.

Shopping/Midday Shuttles

Contra Costa County is notable for two types of shuttle services: (1) privately sponsored midday services linking an edge city and nearby retail plazas, and (2) publicly sponsored connections between BART and downtown Walnut Creek.

(1) *Employer-Sponsored Lunchtime Shuttle: Bishop Ranch*

In addition to supporting the 960 Express Shuttle, Bishop Ranch Office Park pays CCCTA to operate a noon-time shuttle between Bishop Ranch and nearby commercial plazas using 15-passenger vans (Map 5 4). CCCTA in turn contracts out the service. Bishop Ranch employees ride for free upon showing an identification card, while the general public pays a regular fare. Between 11:20 a.m. and 1:20 p.m., the midday circulator links the park to three nearby shopping plazas: Market Place, Crow Canyon Commons, and Diablo Plaza, all popular noontime destinations.

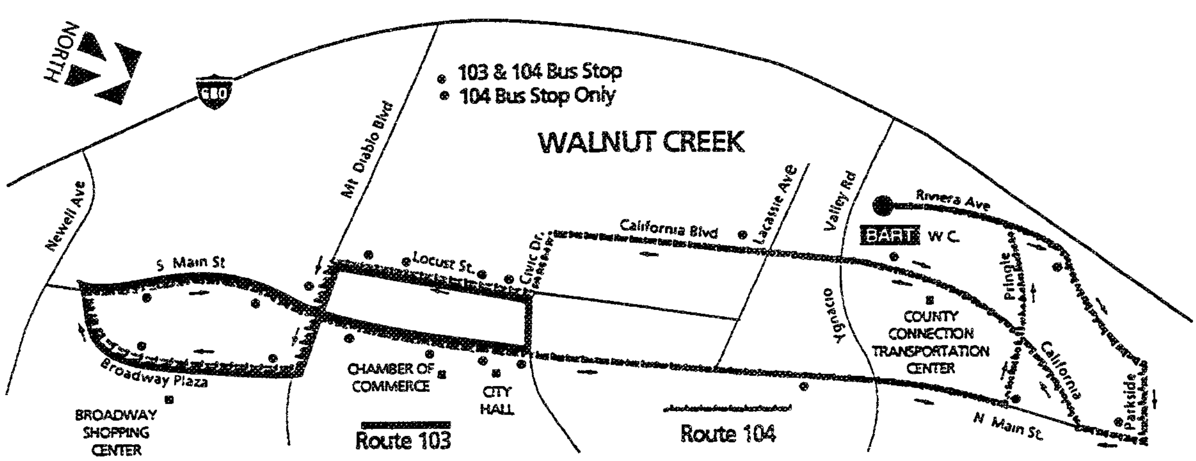


Map 5.4. Bishop Ranch Noon-time Shuttle

The midday shuttle has hardly been a success, as has been the case with all edge-city midday shuttles across the United States.[11] The provision of free parking in outlying employment centers, like Bishop Ranch, generally deters any form of transit-riding in these settings, shuttles or otherwise. In 1994, the Bishop Ranch shuttle carried just 1,100 passengers per month. A year later, this number had dropped to 420 per month. The noon-time shuttle has become CCCTA's most heavily subsidized service – costing over $10 per passenger trip. In an attempt to resurrect and possibly save the noontime shuttle, Bishop Ranch's on-site Transportation Centre has begun aggressively marketing the service, holding lunch-hour "gatherings" that provide free brown bag lunches and discounts coupons for nearby stores for those who attend.

(2) _City-Sponsored Shopper's Shuttle: Walnut Creek_

The City of Walnut Creek sponsors a free downtown shuttle, Route 103, also called the Free Ride, that follows a Figure-8 loop through its traditional downtown (Map 5.5). Following the same path, but also connecting to the city's BART station about a mile to the east is Route 104, which is also free (except on Saturdays when regular fares are charged). Both routes have distinctive logos on their vehicles, and the 103 Free Ride buses have a different color scheme from other CCCTA vehicles as well (Photo 5.1). The city subsidizes both routes; CCCTA operates them Monday through Saturday under a contract. Under the terms of the agreement, the city reimburses CCCTA for the average fare (systemwide weighted across all fare categories) for up to 430 daily boardings (for both routes combined on weekdays, and for Route 103 on Saturdays). CCCTA covers all remaining costs.



Map 5.5. The Free Ride and Route 104

The Free Ride operates from 9 a.m. to 4 p.m. on 5- to 7-minute headways. The 104 circulator operates from 7 a.m. to 7 p.m. weekdays and 9 a.m. to 6 p.m. Saturdays, hours that allow it to serve commuters. Schedules for all a.m. peak buses, and three out of four p.m. peak buses, are coordinated with BART train departures, which CCCTA fairly liberally defines as arriving 5 to 15 minutes before or after a BART train departure.

Walnut Creek has a very pedestrian-friendly downtown, with narrow, tree-lined streets laid on a grid, and several open plazas. The downtown features 70 restaurants, several upscale shopping complexes, and a regional mall, Broadway Plaza. Traffic congestion has worsened as the commercial district has expanded in recent years. The city's aim in subsidizing the service is to reduce secondary auto trips within downtown and to free up curb space for shoppers. In addition to serving BART passengers, the shuttle is also aimed at motorists. By providing a free, convenient shuttle around the downtown, city officials reasoned, shoppers could be encouraged to leave their cars in one of the three city-owned or two private parking garages along the shuttle loop.

Besides serving shoppers, Route 104 was also intended to provide noon-time shuttle access for station-area office workers wanting to reach the downtown restaurants for lunch. Providing midday mobility for office workers was viewed as a possible inducement to encouraging them to commute in a non-SOV mode by relieving them of the need to have a car available for lunch-hour travel. Since the initiation of 103 Free Ride service, 104's runs have been cut back to 40-minute headways at midday (9 a.m. to 4:20 p.m.), making it difficult for office workers to use the service for lunch-time trips to downtown.

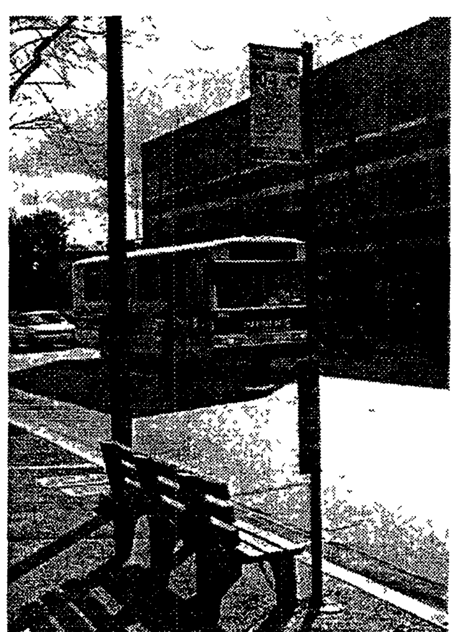


Photo 5.1. The 103 Free Ride. The service is noted for its distinctive color scheme and logo

Walnut Creek aggressively marketed the new shuttle routes. It sought community support through traditional advertising, newspapers coverage, circulating brochures, and hanging banners downtown that announced the services. There was also local television coverage and a ribbon-cutting ceremony. The opening of service was timed for the beginning of the Thanksgiving shopping season, ensuring immediate exposure. The City's efforts to publicize the service had the support of the downtown merchants' association. Many businesses distributed flyers about the service.

The 104 shuttle is one of the most productive routes in the system. For fiscal year 1995, the operating subsidy per passenger trip was $1.11, the lowest in the system With an average of around 500 riders per weekday, Route 104 averaged nearly 22 passengers per revenue vehicle hour.

5.4.2 Past Transit Service Initiatives

Not all of Contra Costa County's efforts to tailor bus services to suburban markets have met with success. Over the past five years, CCCTA has had several failed experiments which shed light on the difficulties of making transit work in low-density. fairly affluent operating environments.

General Public DAR: Walnut Creek Commute Link

The Walnut Creek Commute Link (WCCL) was an unsuccessful attempt to provide curb-to-curb services between the residences of Walnut Creek BART users and the city's BART station. The service lasted only three years, ending in mid-1995. Described as neither a taxi nor a bus, the Commute Link was a collection of "Flex-vans", each van holding 15 passengers that carried residents of the Ygancio Valley Road corridor (the County's busiest boulevard) directly to the Walnut Creek BART station, door-to-door, between peak commute periods from 6:30 - 8:30 a.m. In the afternoon, Commute Link vans would return to the neighborhood by filling up when BART trains arrived at the Walnut Creek station between 4:30 - 7:30 p.m. Afternoon headways were 20 minutes. Reservations were required in the mornings only and at least one hour in advance of pickup time. Thus, WCCL was a hybrid demand-responsive/fixed service -- a dial-a-ride in the morning, a fixed-route shuttle in the afternoon.

The service was a bargain. One-way fares for door-to-door service were just $1.25 for adults/youth, 50 cents for seniors/disabled, and just a quarter for seniors/disabled with a BART transfer. A transfer from BART to the Commute Link was 50 cents, while County Connection transfers were free.

From Table 5.1, we see that daily ridership, though modest, rose nearly 50 percent from 1993 to 1994; so much so that the goal of 40 passengers was surpassed in only one year. However, the net operating cost per passenger trip was still staggeringly high for any mode of public transportation – comparable to an exclusive-ride taxi. The high average deficit (over $6.50 per trip), along with scheduling inefficiencies,[12] led to WCCL's eventual demise.[13] Regardless, passengers really liked the service. In fact, when a public meeting was held on WCCL's proposed abolishment, over 50 residents showed up to protest – which must have been nearly all passengers since

Table 5.1. Walnut Creek Commute Link Performance, 1993-1994

	1993	1994	% Change
Average daily passengers	32	47	+46.9%
Average fare per trip	$0.55	$0.74	+34.6%
Farebox recovery ratio*	5.2%	8.6%	+ 2.4%**
Net operating cost per passenger trip	$9.81	7.85	-20.0%
Operating cost per revenue vehicle hour of service	$21.96	$17.16	-21.8%

* farebox revenues/operating costs
** percentage point change
Source CCCTA, *Ten-Year Short Range Transportation Plan, Fiscal years 1995-2005, 1995*

the service averaged 47 daily riders at its height. Because the Link served a middle- to upper-middle-income neighborhood, critics charged that it was inequitable for county taxpayers to be heavily subsidizing the commutes of a handful of fairly well-off residents. Some called Commute Link "a glorified taxi service", though priced like a bus – a sure recipe for financial failure.

Neighborhood Circulators

From 1992 to 1995, the City of San Ramon in south Contra Costa County operated two 15-passenger vans as circulators within two upper-middle-income neighborhoods within the community. Called the San Ramon Neighborhood Link (SRNL), the competitively contracted service tied to the Stone Ridge Mall in Pleasanton (outside of Contra Costa County, in neighboring Alameda County) and normally ran on 40-minute headways. Fares were a dollar a trip. Because ridership was so low (on average, 2.1 passengers per revenue hour), SRNL was discontinued. As elsewhere across the United States, small-vehicle circulators within residential areas fail to generate enough ridership in large part because of the entrenched motoring habits of suburbanites.

5.5 Performance Evaluation: Factors Contributing to Productive Services

CCCTA has put into place a market-responsive service monitoring and evaluation program. Called a Resources Reallocation Plan (RRP), the plan shifts resources from low to high productivity routes. This has led to on-going service modifications and refinements. In 1995, CCCTA eliminated seven poor-performing routes and expanded several others.

CCCTA's performance data shed light on factors associated with more successful bus runs in traditional low-density, suburban markets. Table 5.2 summarizes key performance characteristics of five of the system's best performing routes and four of the worst. On a passengers-per-vehicle-mile and cost recovery basis, the downtown Walnut Creek circulator, Route 104, rated the highest. Besides the recently eliminated Walnut Creek Commute Link "flex-van" service, the other poor performing routes – Routes 100, 112, and 122 – were conventional fixed-route services. All were subsequently eliminated in a systemwide "purge".

Table 5.2. Performance Comparison of High and Low Performing CCCTA Routes, Fiscal Year 1995

	Passengers/ Revenue Hour	Passengers/ Revenue Mile	Operating Subsidy/ Passenger Trip
Top Performers			
104	19.6	3.5	$1.11
110	19 1	1.3	$1 44
114	23.0	2.1	$1.23
115	17.7	1.7	$1.64
117	17.5	1.7	$1.62
CCCTA Standard	*14.2*	*1.1*	*$2 67*
Poor Performers			
WCCL	2.6	0.3	$9 03
100	9.3	0 8	$4.31
112	9.6	0.6	$4.24
122	8.2	0.4	$8.04

Source CCCTA, *Ten-Year Short Range Transportation Plan, Fiscal years 1995-2005, 1995*

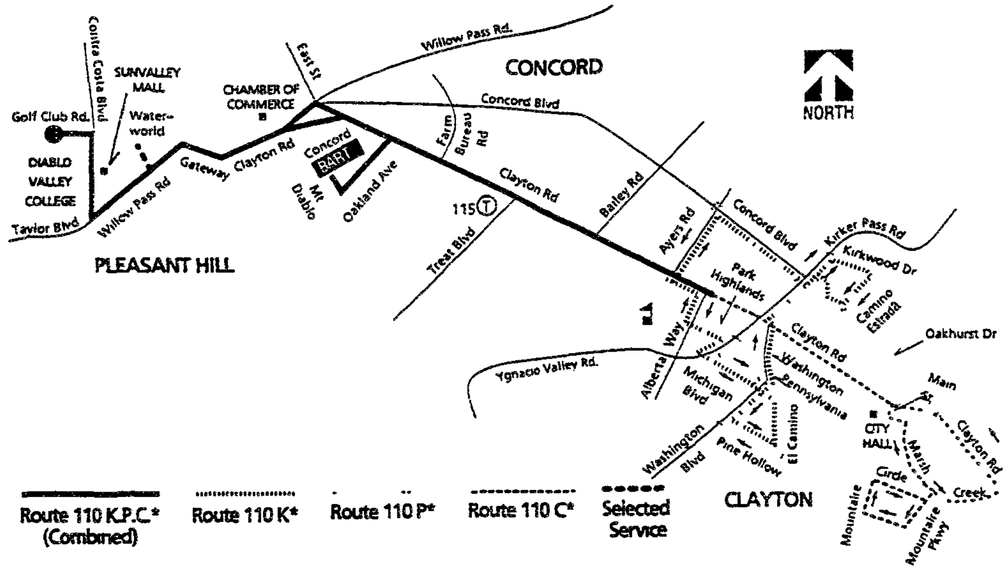
The next section briefly summarizes CCCTA's top-performing routes, followed by a discussion of factors that distinguish these high-performers.

5.5.1 Top Performers

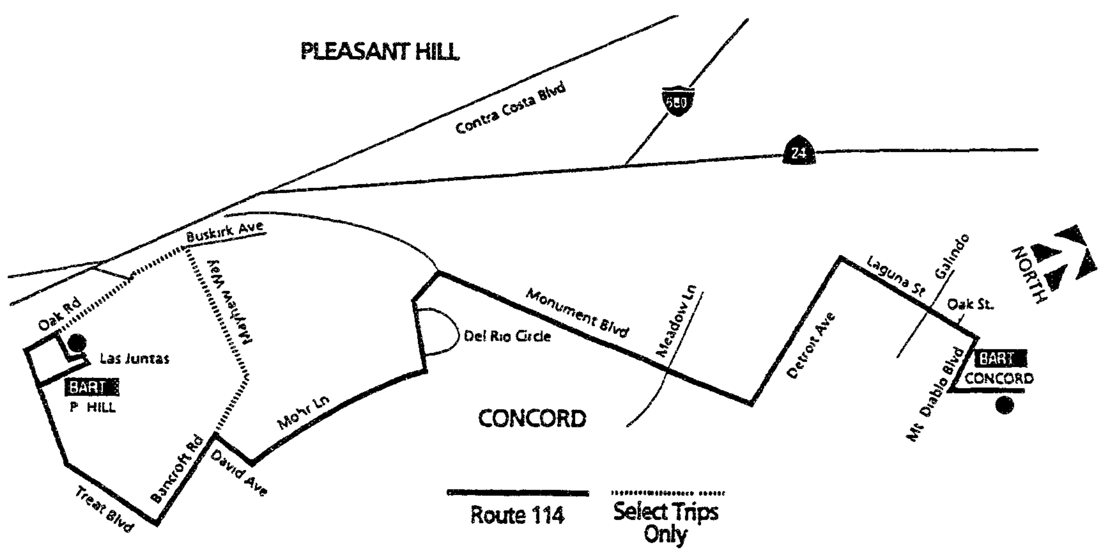
Route 110: Historically this has been the system's strongest-performing route, with consistent year-to-year ridership increases and by far the highest average weekday ridership on the system. CCCTA credits the route's success to high service levels and a dense service area populated by a comparatively high proportion of transit-dependents. Major activity centers along route 110 route include: Diablo Valley College, a community college; two regional shopping centers, Sun Valley and The Willows; and five smaller shopping centers (Map 5.6). The route ties these centers with BART. East of BART it branches into three different residential collectors. Typical peak headways are 30 minutes for each of the collector loops, resulting in 5- to 10- minute average waits between buses.

Route 114: Whereas Route 110 provides a complementary east-west feeder to BART, Route 114 operates north-south, parallel to BART, between the Pleasant Hill and Concord stations (Map 5.7). The route is only 3.5 miles point-to-point. All a.m. peak buses, and 8 of 10 p.m. peak buses, are coordinated with BART train departures. During the 1990s, Route 114 averaged among the highest weekday ridership and service efficiency (23 passengers per revenue hour in 1995) in the system. Its subsidy per passenger trip is one of the three lowest in the system.

As with Route 110, much of Route 114's success can be attributed to high service levels and a comparatively densely populated, transit-dependent service area – both of which tend to be



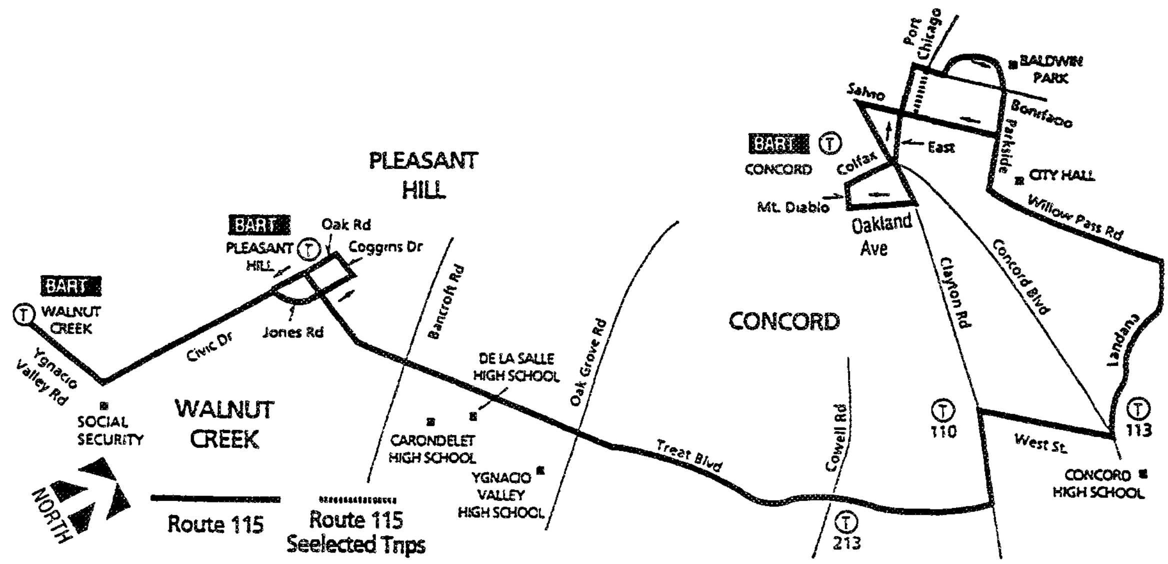
Map 5.6. CCCTA Route 110



Map 5.7. CCCTA Route 114

mutually supporting. Though the route plies mainly along residential streets, it also passes a neighborhood shopping center.

Route 115. This is the only route that serves all three BART stations along I-680: Walnut Creek, Pleasant Hill, and Concord (Map 5.8). It comes as close to a timed-transfer operation as any bus route in the San Francisco Bay Areas. All a.m. peak runs and 85 percent of p.m. peak runs are coordinated with BART train departures. The aim is for buses to arrive within three to five minutes of trains. Mid-rise commercial and office development lies at each of the BART



Map 5.8. CCCTA Route 115

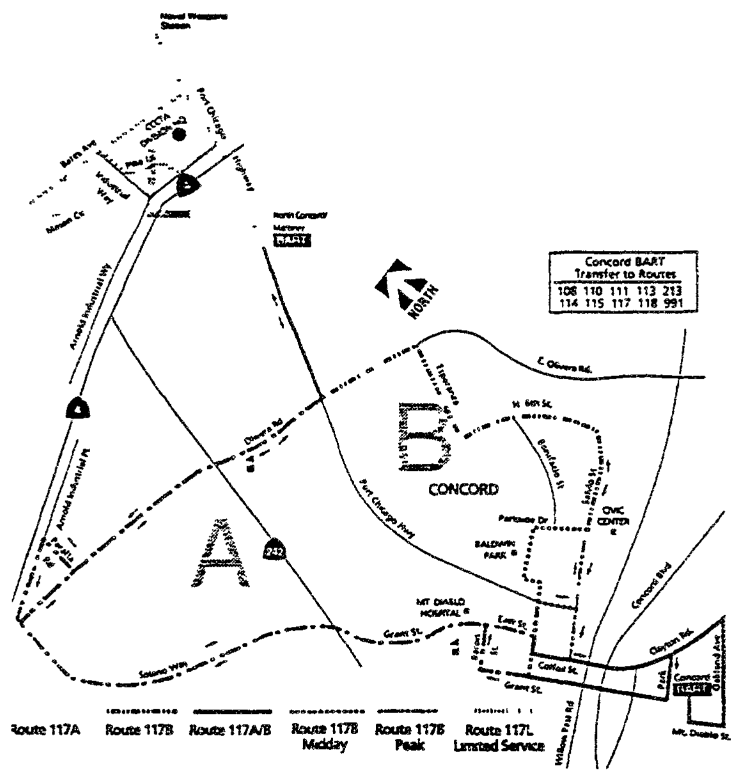
stops. Along Treat Boulevard, Route 115 serves numerous garden-apartment complexes. Other activity centers along the route include five shopping centers and four high schools.

Route 117: This route operates between the Concord and the recently opened North Concord BART station (Map 5.9). It filters through much of downtown Concord, serving single-family neighborhoods to the east and such activity centers as Mt. Diablo Hospital and the Concord Civic Center. A limited peak-hour service (117L) also operates between the North Concord/ Martinez station and the CCCTA Headquarters and the Naval Weapons Station, site of some 500 employees.

5.5.3 Contributing Factors

CCCTA's good-performing routes share certain things in common. Most notably, all serve built-up areas with major activity centers, and operate in areas with transit-supportive demographics. Route 104 and 114 derive part of their advantages by operating over short distances, allowing more frequent seat turnover and resulting in high service effectiveness. Route 110 benefits partly by providing complementary east-west service between activity centers and the mainly north-south BART spine. Pulse-scheduling of Route 114 and 115 with BART trains has no doubt enhanced the performance of these routes.

Next, we briefly compare CCCTA's top-performing and poor-performing routes along three dimensions: density, demographics, and route efficiencies.



Map 5.9. CCCTA Route 117

Density

CCCTA's most productive routes serve relatively dense neighborhoods. Figure 5.1 compares the densities of "high" versus "low" performing routes, with densities measured as 1990 population per square mile for the census tracts traversed by the routes. The graphs also compare population densities between the routes and the city (or cities or unincorporated parts of the county) that the routes operate in. For example, the 1990 population density of census tracts served by the route 110 was 1.36 times that of the city of Concord; the differential is summarized in the right-hand side graph. In the case of Route 114, its corridor densities were nearly twice as high as that of the cities of Concord and Pleasant Hill.

From Figure 5.1 we see that the best performing routes not only averaged population densities that were 30 to 50 percent higher than the lowest performing routes, but corridor densities also tended to be much higher than those of surrounding areas. In central Walnut Creek, the circulator Route 104 traversed neighborhoods with average densities that were more than twice those served by the now-defunct "flex-van" Commute Link.

Density clearly plays a role in inducing bus patronage in the eastern suburbs of the Bay Area. These findings are consistent with those of a long line of research showing density to be one of the most powerful determinants of transit demand.[14] In the Bay Area, studies of travel demand among suburban residents suggest that a doubling of residential densities leads to a 20 to 30 percent increase in transit modal splits, controlling for factors like household income.[15]

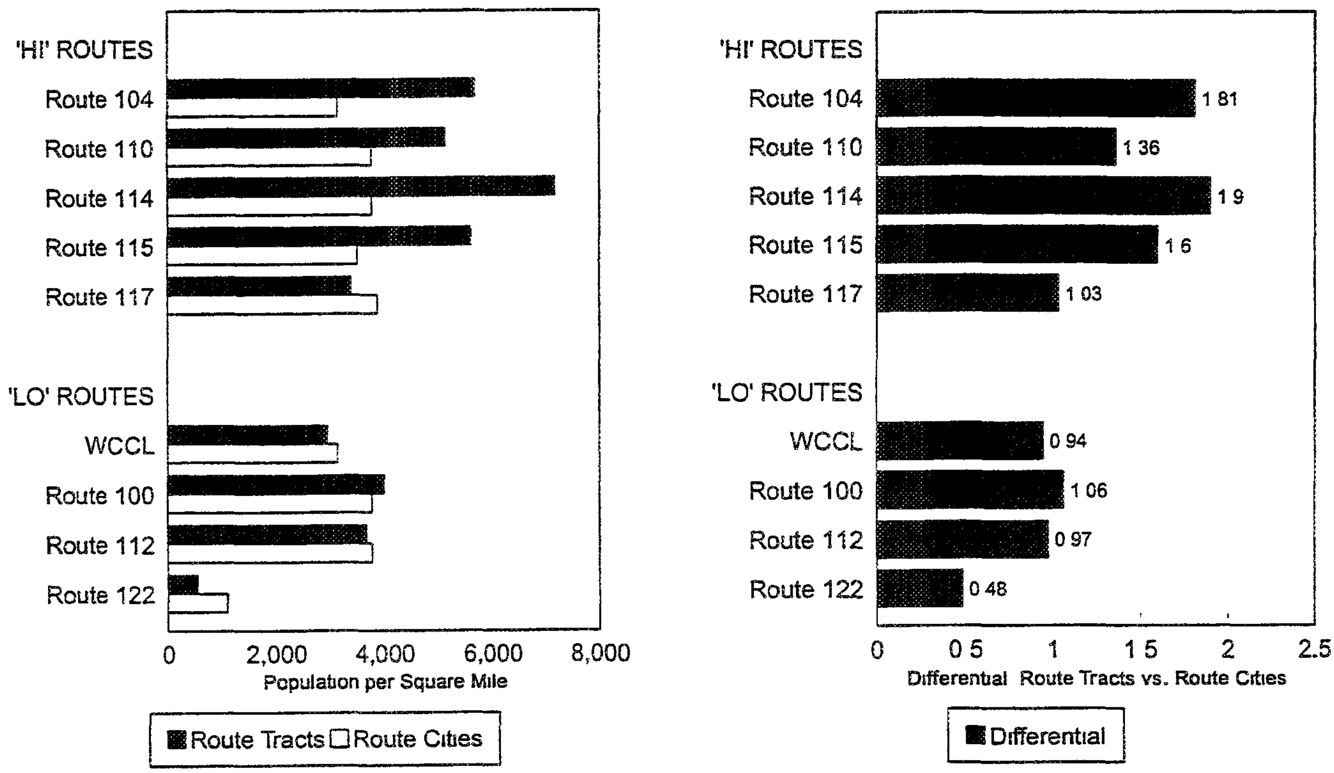


Figure 5.1. Comparison of Population Densities of "Hi" and "Lo" Performing CCCTA Routes, 1990 Density Statistics

Demographics

In addition, the higher performing routes tend to have supportive demographics. Figure 5.2 shows that median household incomes of census tracts served by the most productive routes are considerably lower than those of the poorest performing routes. Their median incomes are also slightly below those of surrounding neighborhoods, reflected by city wide averages. Higher performing routes also tended to average fewer automobiles per household, although the relationships are not as strong.

Route Efficiencies

High ridership partly derives from both the number and type of suburban activity centers served by these routes. Colleges generate ridership steadily throughout the weekday. Shopping centers can draw heavily on weekends and evenings. Medical complexes are usually associated with spread-out demand. Collectively, these factors have attenuated the degree of peaking, allowing resources to be more efficiently distributed throughout the day and week. Efficiency gains also come from service design, such as selective inter-lining of routes[16] and limited pulse-scheduling.

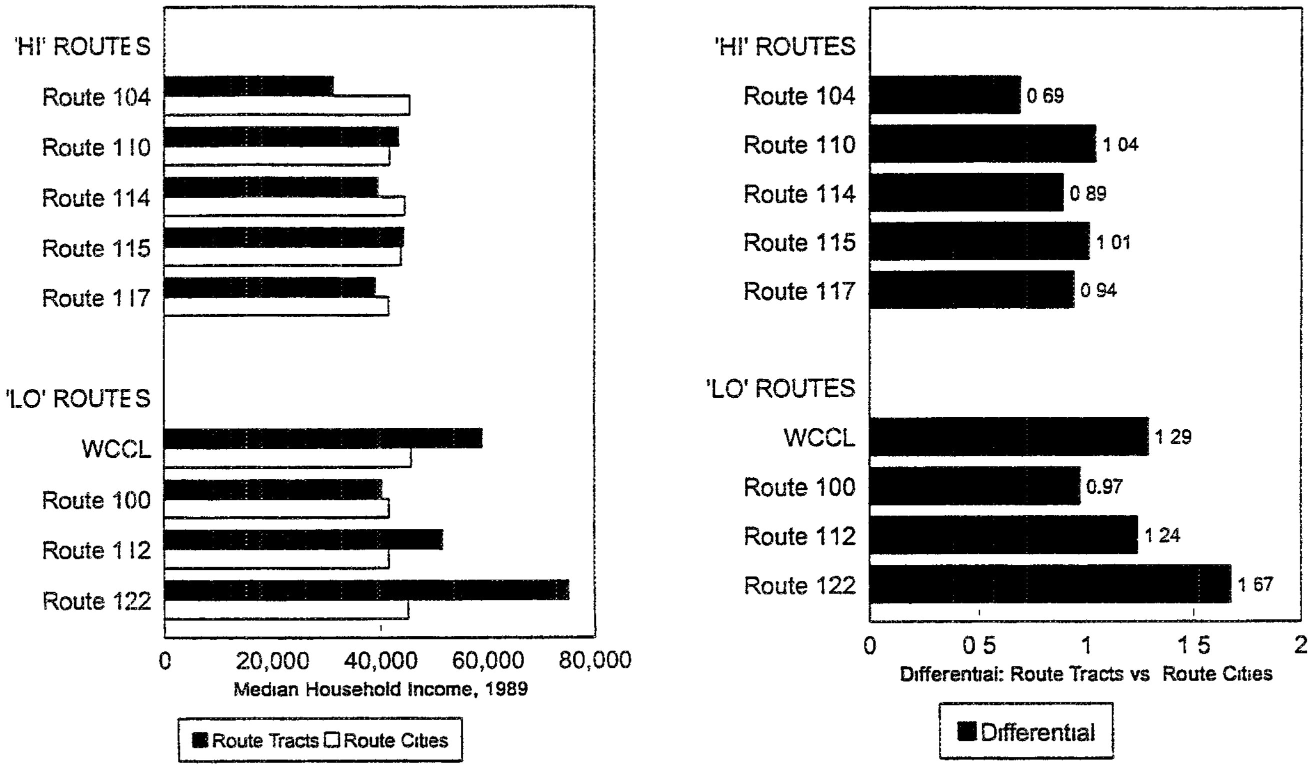


Figure 5.2. Comparison of Median Household Income Characteristics of "Hi" and "Lo" Performing CCCTA Routes, 1989 Income Statistics

5.6 Other Exemplary Initiatives in Contra Costa County

5.6.1 Intermodalism

All County Connection routes serve at least one BART station, and as the number of bus-to-bus transfers increases, BART stations increasingly serve as transfer points within the CCCTA system. Agency officials work closely with BART to facilitate transferring, both through station design and schedule coordination.

BART designs intermodal facilities to efficiently accommodate bus maneuvers, to ensure safety, and to make transferring convenient. Within its stations, bus staging areas are designed to provide sufficient turning radii and layover facilities for buses, space for shuttles, and prevent conflicts between buses and passenger cars (e.g., taxis, kiss-and-ride, passenger pick-ups). The sawtooth boarding bay arrangement at most stations allow buses to pull in and out easily, albeit at the cost of sometimes creating long walks to the fourth or fifth bus in a line. This configuration also makes buses more easily identifiable, thus easing passenger transfers (Photo 5.2).

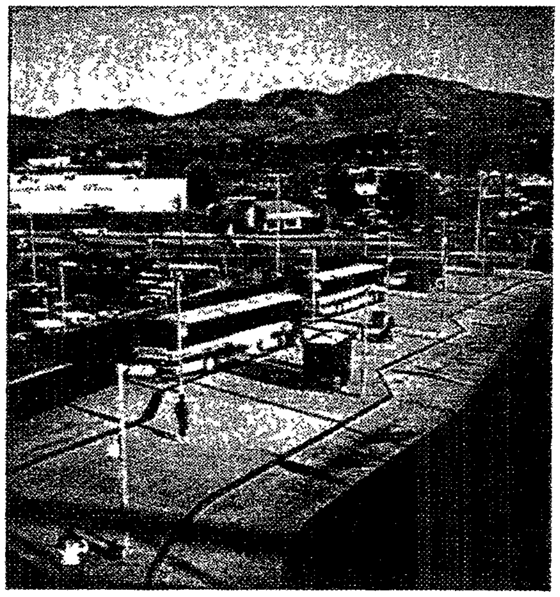


Photo 5.2. Sawtooth arrangement eases identification of buses in making transfer

5.6.2 Marketing

CCCTA markets its service like most other U.S. bus properties: through fare incentives, public announcements, and newsletters. One of CCCTA's most important marketing assets is the County Connection Transportation Center. Located directly across the street from Walnut Creek BART, the Center calls itself "a one-stop shopping center for today's busy bus rider". Open from 6 a.m. to 7 p.m. on weekdays, the Center provides full customer information and services: sale of multi-ride punch cards, BART tickets, and the Regional Transit Connection Discount Card; personal trip planning; telephone and web-site information; and the handling of customer complaints and suggestions.

5.6.3 Institutional Initiatives

Besides coordination among public transit operators, Contra Costa County is also noteworthy for other institutional responses to transit planning needs. One has been the formation of a consortium of five cities in the county – Clayton, Concord, Martinez, Pleasant Hill and Walnut Creek – and all unincorporated areas of Contra Costa County into an informal subregional transportation planning organization called Transpac (short for Transportation Partnerships and Cooperation). Transpac is a volunteer corporation that makes planning recommendations as well as designs TDMs for Contra Costa County. As a volunteer organization, it has no direct power to enforce plans or recommendations; however, the recognition among member jurisdiction that transportation must be coordinated subregionally has made Transpac an important political force in the area. Transpac staff has worked with BART and CCCTA to coordinate service improvements; one example was putting HOV lanes on Highway 680 to encourage carpooling to relieve congestion.

5.7 Lessons from Contra Costa County

Several lessons stand out from central Contra Costa County's efforts to adapt bus transit services to suburban markets:

- Public-private partnerships are essential in mounting successful express shuttle services. Working together, CCCTA's experiences show that transit agencies, employers, and developers can design equitable cost-sharing agreements for financing specialized services.
- CCCTA's experiences underscore the value of aggressive service monitoring and evaluation. Over the years, the agency has continually sought to modify, refine, and upgrade services. As the county continues to grow and travel patterns become more complex, service design will only gain importance with time.
- In suburban markets, densities and demographic composition can have a strong influence on productivity. The significance of density as an explainer of route performance lends credence to the importance of selective land-use strategies as means of inducing ridership gains.
- Successful services also tend to link major activity centers, especially those that generate ridership evenly throughout the day and week (e.g., college campuses, medical centers).
- By creating a multi-destinational, hub-and-spoke system, CCCTA has been able to design its routes to complement and function as "quasi" timed-transfer feeders into mainline BART services. This has generally worked well for those routes that meet other prerequisites for successful services, like minimum density thresholds and supporting demographics.

Notes

1 Capital depreciation are included in costs figures; however, debt service expenditures on capital are not

2 The BRMB was created by developers' initiative. It represents the employees of two companies that lease space from Bishop Ranch as well as employees of two of the park's landowner corporations. The Association has historically sponsored transportation services and represented the interests of the park on areawide transportation matters. In more recent years, transportation functions have been assumed by the Bishop Ranch Transportation Centre.

3 The private shuttles, contracted out to private operators, ran on 30 minute headways from 7-9 a m and 4-6 p.m Shuttle runs were free to employees of offices leasing space in Bishop Ranch. At the time, Bishop Ranch's two largest tenants, Pacific Bell Telephone Company and Chevron Corporation, also operated 7 daily commuter shuttle runs, using 2 buses and charging employees a dollar a ride; by the early 1990s, both of these services were canceled because of escalating costs and a business recession The abandoned shuttle services were subsequently picked up by CCCTA and BART

4. Sunset Development Company took transportation seriously early on, hiring a transportation manager (at a Vice-President level) well before trip reduction mandates were legislated. The company has written in

every employer's lease a clause in which a percentage of monthly rent goes to subsidizing workers to take public transportation.

5. Part of the reason for the jump was the complete elimination of Bishop Ranch's in-house shuttle services, which sent some of its former passengers to Route 960. Ridership has also been drawn from the BART express, a BART-contracted limited-stop service that also operates between Walnut Creek and Bishop Ranch. BART Express operates every half hour during rush-hour traffic and every hour during non-rush-hour times. It charges a $1.25 per ride and is not as heavily patronized. During off-peak hours, it averages just 3.5 passengers per bus run from Walnut Creek to Bishop Ranch and then on to the Stone Ridge Shopping Mall in Pleasanton to the south.

6 The region's air quality board, the Bay Area Air Quality Management District (BAAQMD), has established VER goals for large employers (over 100 workers) and large multi-tenant complexes for different parts of the region under the Regulation 13 trip reduction program. The targets reflect the availability of transit, existing commute options, and land-use attributes of the workplace.

7. Bishop Ranch is looking to expand service to the new Dublin/Pleasanton BART station, around 5 miles south of the park in Alameda County. This new rail node provides a tremendous opportunity to attract more workers to an all-transit (rail-shuttle) commute. Presently, around one-quarter of the Park's employees live within either Dublin/Pleasanton or near BART stations along the Fremont line in southern Alameda County. This southern shuttle would complement the existing northern (Route 960) shuttle to Walnut Creek, hopefully creating a critical mass of riders and scale economies. It would likely also aid Bishop Ranch in meeting its VER targets.

8. When the Airport Plaza business park opened about a mile north of the Concord BART station in 1985, its anchor tenant was Wells Fargo Bank's credit division, which had relocated from downtown San Francisco. Initially, the property manager for Airport Plaza contracted with CCCTA to operate a shuttle exclusive for the park's employees. Some 15 employee vanpools were also set up by Wells Fargo, and a few of these lasted under the early 1990s, when they were phased out because of the economic downturn and rising costs, replaced by the Route 991 express shuttle and the Route 118 back-up.

9 The cost of Route 991 is calculated by multiplying the total number of boardings each month by the system-wide average fare. After the cost of any full-fare (non-employee) passengers, who in a typical month might account for about 30 boardings, is subtracted from the total, the remaining cost is divided among the three business parks according to ridership data collected by CCCTA.

10 The property manager for Airport Plaza is satisfied with the 600 or so monthly trips made on Route 991 by its on-site employees. In addition, around 1,400 trips per month on Route 118 are billed to Airport Plaza's management. Airport Plaza's management believes its sponsorship of shuttle runs has taken around 2,000 cars off of Contra Costa County roads per month Airport Plaza views the shuttle as part of the complex's regulatory operating expenses; as long as the service is being reasonably well patronized and costs do not rise dramatically, its owners plan to continue supporting the service. Chevron U.S.A takes the position that company is obligated to support the service under its current agreement. Since Chevron operates its own vans – it currently runs an inter-campus passenger shuttle between Chevron facilities in the Bay Area – it could operate a BART express service in-house if Route 991's costs become too high. With just 10-15 Chevron employees patronizing Route 991 each day, Chevron finds the approximate subsidy of $5 per ride to be reasonable. While paying for taxi rides might potentially be cheaper, they would likely be less convenient and reliable SRS Development, the property management company for

Galaxy Office Park, presently pays around $250 per month for Route 991 services, a modest enough sum to make the subsidy a "non-issue" for the company.

11 Urbitrans Associates, Multisystems, SG Associates, and R. Cervero, *Improving Transit Connections for Enhanced Suburban Mobility*, Washington, D.C , Transportation Research Board, TCRP B-6, 1997.

12. The Community Link was very accommodating of customers wishes It would pick up residents at their door anytime between 6 and 8.30 a.m. No effort was made to schedule pick-ups to allow for efficient, consolidated connections. Sometimes 15-passenger vans would arrive at the station with just 2 or 3 passengers.

13. CalTrans subsidized the service as part of its I-680/Highway 24 mitigation program. CalTrans reimbursed the private operator the difference between the fare income received and the contracted cost per hour. CalTrans decided not to renew the contract because of the high deficits per rider

14. See R. Cervero and S Seskin, *An Evaluation of the Relationship Between Transit and Urban Form*, Washington, D C.: Transportation Research Board, Transit Cooperative Research Program, Research Results Digest, No. 7, 1995; and B. Pushkarev and J Zupan, *Public Transportation and Land Use Policy*, Bloomington. University of Indiana Press, 1977.

15. J Holtzclaw, *Residential Patterns and Transit, Auto Dependence, and Costs*, San Francisco· Resources Defense Council, 1994; R. Cervero, Surviving in the Suburbs, *Access* Vol. 1, No. 2, pp 30-35, 1993.

16. Interlining occurs when a bus at the end of a route switches to a more productive line rather than deadheading or returning in a direction of slack demand

PART TWO

TECHNOLOGICAL-INNOVATIONS

Part Two examines experiences in two case-study areas where the focus of adaptive transit improvements has been on technological improvements that provide high-performance, but flexibly operated, bus transit services: (1) Karlsruhe, Germany, and (2) Adelaide, Australia.

Chapter Six

Adaptive Light Rail Transit and Track-Sharing: Karlsruhe, Germany

6.1 Synopsis

Karlsruhe, Germany, has pioneered a system of track-sharing that integrates inner-city tram and inter-city heavy rail services. By tying into German Railway tracks, Karlsruhe has managed to extend the reach of light rail services at a fraction the cost of constructing a new suburban railway. Most importantly, by running dual-voltage light rail vehicles on central-city tramways and regional rail tracks, Karlsruhe has engineered a versatile form of light rail services that virtually eliminates the transfer. The payoff has been a healthy rise in transit patronage over the past decade, despite a downward ridership trend in the rest of Germany While well tailored to the region's spread-out settlement pattern, Karlsruhe's dual-mode form of light rail transit has also blended nicely with pedestrian-only commercial districts, both in the city itself and in numerous small towns aligned along suburban rail corridors. In greater Karlsruhe, one finds a harmonious fit between transit technology and cityscape that is one-of-a-kind.

6.2 Adapting Transit to Low-Densities in Germany

Light rail transit has become the technology of choice in most cities seeking to join the modern rail transit age. Yet light rail transit often struggles to compete with the private automobile outside of central cities, in large part because suburban patrons must make "the dreaded transfer" when connecting to a light rail station. Karlsruhe, a medium-size city in southwest Germany, has made tremendous strides in eliminating transfers by pioneering an incredibly versatile form of light rail service, one where LRT vehicles run on both citywide tram tracks and intercity high-speed rail tracks. In Karlsruhe, the same vehicles that crawl along the main pedestrian street, Kaiserstrasse, at 4 to 5 km per hour, transform into efficient line-haul carriers when they exit the city, blazing along tracks owned by the federal railway authority at close to 100 km per hour, shoulder-to-shoulder with high-speed trains heading to Bavaria and beyond. This adaptation of transit technology to the region's spread-out lay of the land has meant the same vehicles providing point-to-point line-haul services also function as inner-city circulators, not unlike a busway system. While fortuitous circumstances, like the presence of an extensive federal railway network in its hinterland, played a big role in the formation of Karlsruhe's unique hybrid services, the lessons Karlsruhe offers on creatively adapting light rail services to low-density environs have relevance to many places with or contemplating light rail services.

6.3 Inventing a New Form of Light Rail Transit

Why Karlsruhe, one might ask? Karlruhe's foray into the enterprise of creating new transit technologies is a product of history, public choices, and personalities. Founded in 1715, Karlsruhe was master-planned as the capital of Germany's newly formed state of Baden-Württemberg. Its extensive network of wide streets – 23 radiate from the city's imposing castle, overlaid by an elongated grid connecting the castle to the Rhein River to the west – today stands in marked contrast to the medieval cores of many German cities. Wide streets would eventually prove to be a blessing, allowing Karlsruhe to expand and upgrade its tram network, in existence since the late 1800s, at a time when many German cities were paring back theirs.

Karlsruhe grew rapidly, both in people and cars, during Germany's post-war reconstruction period. By the early 1970s, a time when downtown Karlsruhe had free and plentiful parking and no pedestrian precinct, urban trams were losing customers to the car in droves. One by one, tram lines were being replaced by buses. As elsewhere, Karlsruhe's public transit system was caught in a vicious circle of declining transit ridership and service cuts. It was during this period that an important decision was made by city leaders: to become an active player in the suburban travel market by becoming a regional transit service provider. By forming a regional transit agency, AVG (Albtalverkehrsgesellschaft), as a counterpart to the city transit operator, VBK (Verkehrs-betriebe Karlsruhe), the institutional apparatus was in place to expand public transit's territory of operation. Both AVG and VBK are owned by the city of Karlsruhe. Through AVG, the city has negotiated contracts with local communities in the region to help pay for services provided.

The region's acquiescence to market-driven growth during the postwar period further set the stage for transit innovations. While the city of Karlsruhe itself is fairly compact, with some 280,000 residents in an area of 173 km^2 (much of it parkland), many of the remaining 800,000-plus inhabitants of metropolitan Karlsruhe (2100 km^2) live in villages and small towns surrounded by rolling countryside and forests. There has been little regional effort to orchestrate where growth occurs, largely in deference to consumer preference for detached housing. To the credit of Karlsruhe's civic leaders, it was recognized early on that city-sponsored transit services operating outside the city boundaries needed to effectively respond to and serve spread-out development. Metropolitan form, it was understood, defined the parameters around which good quality public transit services had to be designed.

The only kind of transit service that would effectively compete with the car in suburbia, it was reasoned, would be one that emulates the car – providing seamless, door-to-door connections that eliminate the physical act of transferring as well as the added penalty of having to pay extra fares. In medium-size cities like Karlsruhe where virtually all households have a car (500 per 1,000 residents in 1996), frequent transferring, it was concluded, would be transit's death knell.[1] Yet until dual-mode transit services were introduced in the early 1990s, transferring was a way of life for suburban transit patrons headed to Karlsruhe city and its main shopping precinct, Kaiserstrasse. This was largely because the main station of the German railway (Hauptbahnhof) in Karlsruhe is situated on the city's edge, and over the years heavy rail tracks and services have been oriented to this peripheral location. Thus, inter-city and regional rail services into Karlsruhe, operated by both the city (AVG) and the German national railway (Deutche Bundesbahn, or DB), historically have terminated at a station far removed from the destination of most passengers, requiring a connecting tram ride and extra fare.[2]

The adopted policy of eliminating time-consuming transfers led to the creation of Karls-ruhe's own unique breed of transit service, the Stadtbahn, or S-Train. Not to be confused with the S-Bahn, the single-mode suburban rail services of large German cities like Berlin, the S-Train was conceived as a blending of modes (urban tram and inter-city heavy rail) and operating environments (city and countryside). The basic idea was to integrate mainline and feeder services using a single vehicle. This required a highly versatile type of train, one capable of operating slowly and in harmony with pedestrians while in the core, and quickly and in harmony with heavy freight trains along mainline stretches outside the city. It also required an extensive network of suburban rail trackage, something which the region already had, being criss-crossed by heavy rail DB passenger and freight lines linking Stuttgart and Frankfurt. Since the regional operator, AVG, had already successfully run trams along disused DB freight tracks, a logical next step was to do likewise along the extensive network of active DB tracks.[3] For AVG's General Manager, Dieter Ludwig, who provided much of the vision and leadership in pioneering Karlruhe's hybrid transit services, the region's extensive DB network was an asset that had to be fully exploited if integrated and seamless regional transit services were to become a reality. Ludwig saw an opportunity to provide an S-Bahn type of service, as in Munich and Frankfurt, without the expense of conventional S-Bahn construction. However, as he saw it, Karlsruhe's S-Trains would actually outperform the train services of Germany's larger cities by tying together suburban and inner-city services under one vehicle.

With local support and the eventual buy-in of the German Railway, DB, starting in the mid-1970s, at a time when many cities were dismantling their tram networks, Karlsruhe began upgrading its transit offerings from a standard urban tram operation to a hybrid light-rail/heavy rail regional system. This was done largely through innovation – designing and building a dual-mode LRT vehicle and adapting it to the heavy rail tracks of the German Railway. Also important were various supportive measures: formation of a regional coordinating entity, the Karlsruhe Verkehrsverbund (KVV), devoted to integrating network timetables and fares; construction of new and reshaping of existing tracks; and refurbishment of old disused railway tracks.

In the quest for transfer-free services, why, one might ask, did Karlsruhe not opt for a more conventional, "off-the-shelf" technology – namely, buses operating on dedicated rights-of-way? Part of the answer lies in Germany's tradition of first-rate rail services and a cultural predilection for speed, comfort, and convenience. In a land of Mercedes and BMWs, high-speed trains, and hyper-speed Autobahns, Germany's urban transit systems must provide a very high quality of service if they are to compete The choice to go with dual-mode rail rather than busways stemmed from the belief that, in Germany at least, rail travel is preferable. Karlsruhe transit officials maintain that even if a bus journey takes the same time and is as comfortable, people still overwhelmingly prefer rail. Recent ridership surveys bear this out: most of the region's bus riders are captives (only 3 percent had cars available in 1994) while much higher shares of rail passengers are choice riders (20 percent of Karlsruhe residents riding trams and 40 percent of dual-track, S-Train customers had cars available in 1994).[4]

The attention given to quality and image carries over to the details of service design. For example, the interiors of all trains serving greater Karlsruhe are free of advertising so as to make them more visually appealing to middle-class riders. As a matter of policy, all graffiti is immediately removed, even if it means taking a train out of service. Low-floor trains that allow convenient and expeditious boarding and alighting have also become the norm. Most recently, the city has begun operating four rail cars with small center-section cafes. In Karlsruhe, the mind-set of providing extraordinarily high quality urban transit services pervades the entire transit operation

6.4 Principles of Adaptive Light Rail Transit

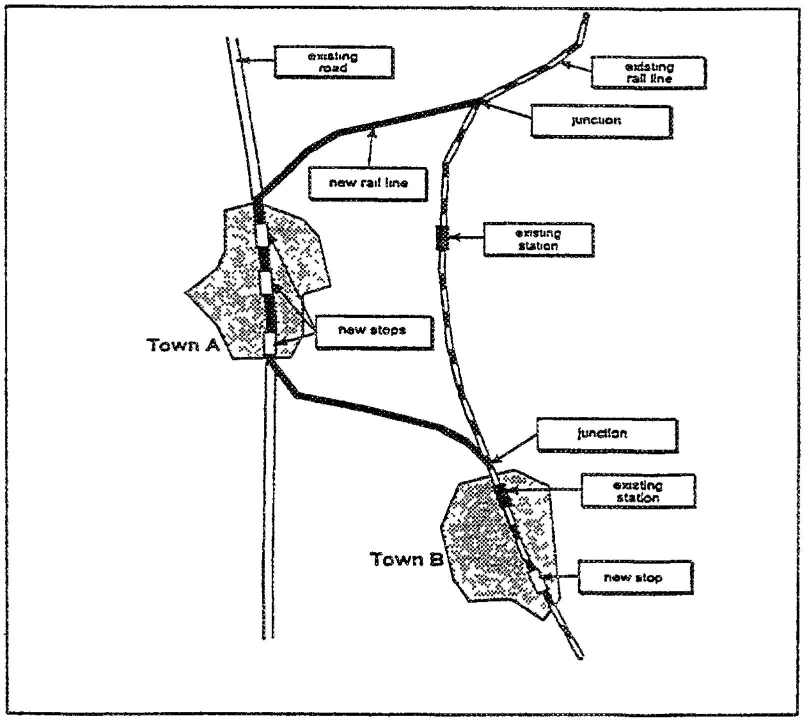
The precepts of what was to become Karlsruhe's S-Train services were defined in a 1984 feasibility study conducted by the regional operator, AVG, and funded by the federal government. The study advanced three design principles:

(1) *dual-system vehicles*: a new form of light rail transit was to be created, capable of operating on the regional DB heavy rail tracks as well as the city's tram tracks;

(2) *junctions*: tracks would be inserted at strategic locations to connect DB heavy rail line and Karlsruhe's inner-city tram system; and

(3) *improved access*: new stops would be added along existing railway lines and branch lines to town centers constructed so as to shorten rail access distances.

These principles, shown in schematic in Figure 6.1, formed the foundation for building integrated suburban transit services. While through-running of trains would eliminate transfers, the addition of stations and spur lines to town centers would bring people closer to stops, allowing for more door-to-door service possibilities.



Source C Jefferson and A Kuhn. Multimodal LRT Vehicles. A Development for the Future? *Urban Transport and the Environment II*, J Recio and L Sucharov, eds (Barcelona Urban Transport 96, 1996).

Figure 6.1. Design Schema for Integrated Light Rail Transit

It was the ability to share tracks that crystallized Karlsruhe's commitment to a new form of light rail technology. Some changes to business-as-usual were needed. While conventional trams could match the gauge of DB heavy rail tracks, they would be too slow in providing mainline services. And inter-city trains would be far too heavy to operate on city streets, exceeding the weight limitations of bridges and underground water and sewerage lines.[5] Shared-track services would necessitate the design of a new type of light rail vehicle, one that blended the physical and operating features of a city tram and a heavy rail train.

6.5 Creating a Hybrid Vehicle

The first hurdle that had to be overcome in designing a new breed of light rail transit was the need to operate on different power supply systems. Shared-track vehicles had to be designed that could operate at 750 volts dc on city tramways and 15,000 volts ac on heavy rail DB tracks. Vehicles also had to be nimble enough to safely operate as conventional trams on regular streets, alongside pedestrians and cyclists, yet sturdy and robust enough to mix with heavy rail passenger and freight trains on mainline tracks. Specifically, they had to be able to near-instantly stop when encountering pedestrians yet withstand a collision with a freight train. Given these charges and supported by a grant from the Federal Ministry of Technology, a small team of AVG engineers, led by Dieter Ludwig, in concert with several German rail manufacturers, proceeded to design a hybrid light rail vehicle that would fit the bill.[6] After carefully reviewing statistics on all train accidents that had occurred on Germany's rail network over a 30-year period, the team opted for an 8-axle bidirectional articulated unit developed on modular principles. While dual-mode locomotives adapted to multiple voltage systems have been used in Europe since the 1960s, adapting the technology to light rail vehicles was far more challenging because of the need to conserve space and avoid overly weighing down the vehicle.[7] Electrical hardware that converts 15,000 volt ac power to 750 volts dc was installed in a center section that has an extra bogey (Photo 6.1) Transformers and rectifiers were placed below the floor and special high-voltage switchgear was sat atop the roof, leaving interior space to passengers. Technically speaking, the dual-system vehicle is an alternating current (ac voltage) vehicle with its own rectifier substation on board.

The greatest challenges in bringing a hybrid light rail vehicle on line were institutional, not technical. Notably, DB officials were skeptical whether a light rail vehicle could ever meet Germany's stringent crashworthy standards. Upon numerous computer simulations of potential collision incidences and several months of field-testing a prototype dual-voltage light rail vehicle, Karlsruhe's designers demonstrated to the satisfaction of all that hybrid vehicles and DB trains could safely co-exist. Federal authorities soon thereafter gave a green light to proceed with implementing shared-track services. Two factors, in particular, helped to allay fears over safety. One, the vehicle's light, modular, flexible frame, which evenly transfers kinetic energy throughout the chassis, proved far better at absorbing a train crash than was thought possible. Second, the vehicle's highly responsive disk braking system, installed to provide quiet, soft, but quick stoppage in pedestrian zones, provided superior acceleration and deceleration capabilities relative to heavy rail trains. While the hybrid light rail technology scored lower than heavy rail trains in passive safety (i.e., crashworthiness), it rated much higher in active safety (i.e., ability to avoid accidents). Because of the vehicle's fleetfootedness, DB officials confided that a hybrid light rail train sharing tracks might actually be safer to travel in than their own heavy rail trains. The field

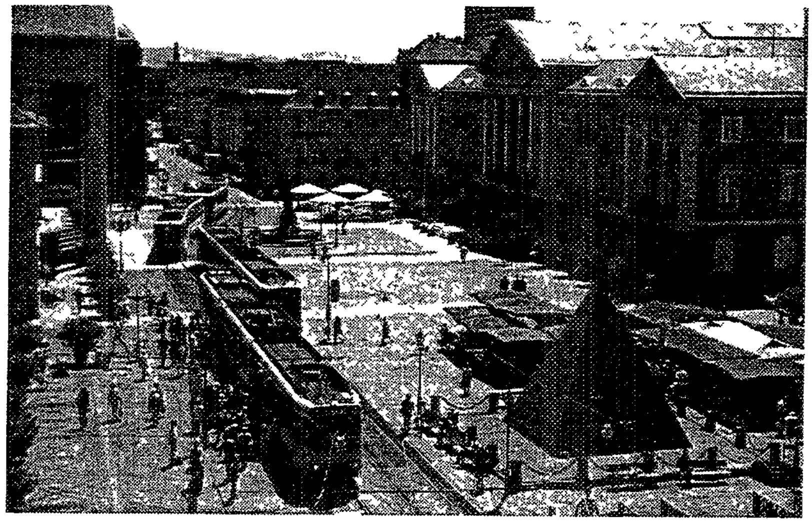
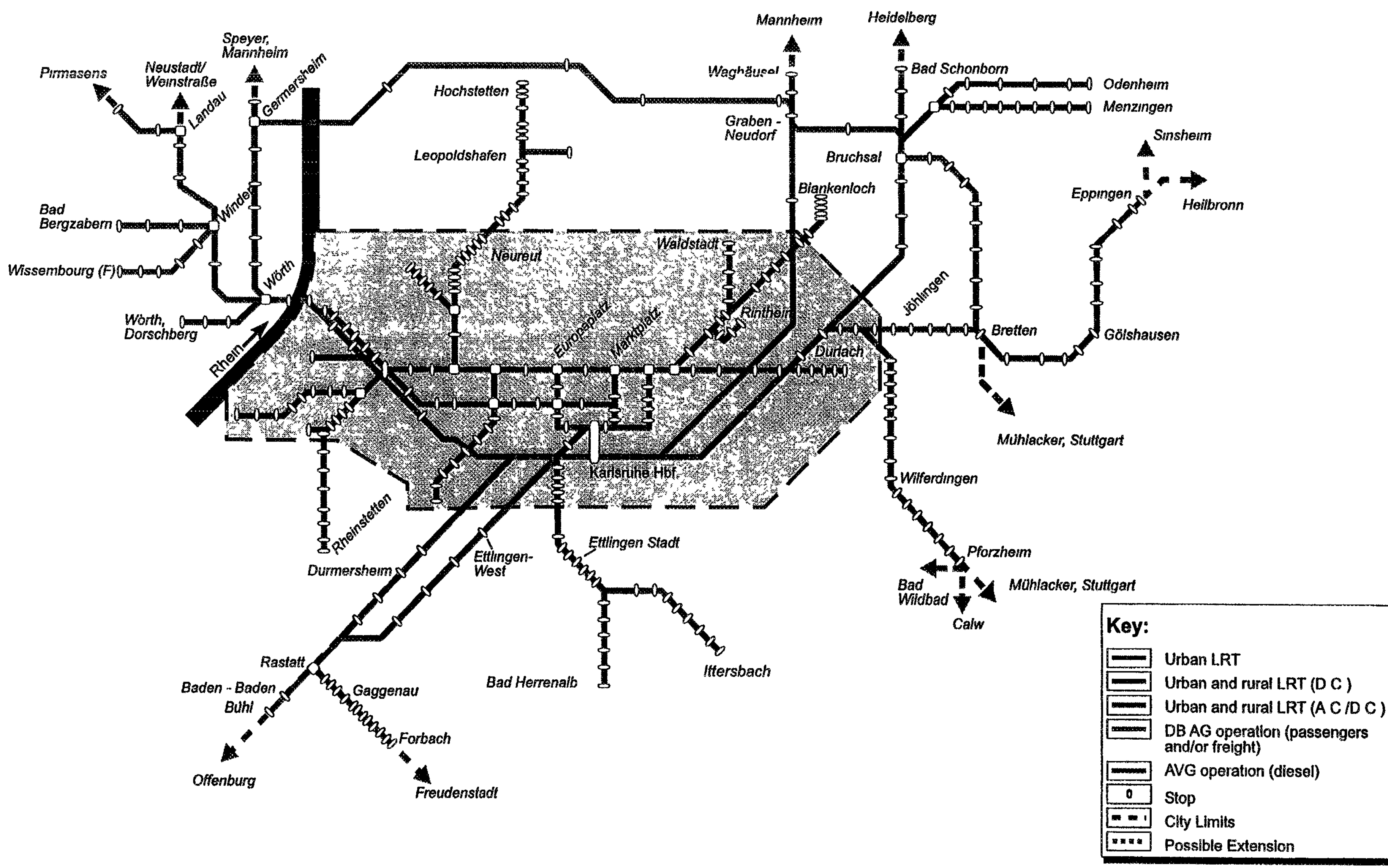


Photo 6.1. Dual-Voltage S-Trains in the Core of Karlsruhe. S-Trains queue for customers at Marktplatz in the heart of the city. The center section of the bi-directional articulated vehicles accommodate the dual-voltage electrical hardware. Speeding up S-Trains within the city limits is a system of induction loops imbedded in surface streets that allow signal preemption. S-Trains are permitted to travel as fast as 50 km per hour while in the city.

test runs of prototype vehicles along DB tracks between Karlsruhe and Pforheim also showed that, because of faster acceleration and deceleration as well as lighter weight, LRT vehicles were 7 minutes faster than DB trains operating on the same route. This finding convinced DB authorities that stations could be added along shared-track corridors without increasing overall risk.

In late 1988, a full agreement was reached to implement the first segment of shared-track passenger services, between Karlsruhe and Bretten, some 28 kms to the east.[8] (See Map 6.1 for Karlsruhe's rail transit network.) Besides making electrification improvements, new branch lines, junctions, stations, and double-track sections were added to the corridor (Photo 6.2). Completed and opened to service in 1992, the $45 million DM (US$30 million) price tag was around a tenth what an underground S-Bahn type rail system would have cost.[9]

Institutional and regulatory reforms, it should be noted, were absolutely essential in moving Karlsruhe's shared-track, hybrid light rail service from concept to reality. The German government's decision to functionally separate track ownership (a public sector responsibility) from train operations (open to the private sector) provided a receptive institutional environment for track sharing. In years past, DB would have viewed light rail trains running on its tracks as unwanted competition and a potential nuisance. To the now privatized DB, track-sharing was viewed as a potential source of revenue. Local observers also note that a close professional relationship between Karlruhe's transit chief, Dieter Ludwig, and the head of DB's local office for short-distance train services was instrumental in negotiating a track-sharing agreement.



Provided Courtesy of TransportTechnologie-Consult Karlsruhe (TTK), GmbH

Map 6.1. Metropolitan Karlsruhe's Rail Transit Network

Photo 6.2. Switching from City Tram Tracks to DB Heavy Rail Tracks. An S-Train enters a junction connecting the city tram tracks and the DB heavy rail tracks along the eastern line to Bretten and Eppingen. The actual conversion of power source occurs along a neutral straightaway section of the junction that allows vehicles to coast at zero voltage for some 180 m. On-board equipment recognizes the neutral section and automatically opens the main circuit breaker. (If the circuit breaker fails to open within 3 second after reaching the neutral section, the pantograph is automatically lowered and can only be raised again if the circuit breaker is open.) As soon as the new voltage is detected, the appropriate circuit is selected, without any action required by the driver, and the main circuit breaker closes again

6.6 Metro Light

Following the initial extension to Bretten, nearly 300 km of shared-track rail services had been introduced in metropolitan Karlsruhe by 1997. Through careful planning and execution, what was only two decades earlier a conventional tram and commuter rail network has today evolved into a metropolitan-wide transfer-free light rail service – "metro light" – superbly adapted to the region's spread-out settlement pattern. Karlsruhe's rail network successfully combines the best features of conventional trams and heavy rail metros. By this is meant:

- *cost-effectiveness:* expands the reach of transit services beyond central cities at a fraction of the cost that would have been incurred in laying new tracks;
- *line-haul efficiencies:* delivers fast, point-to-point services in the suburbs, making light rail time-competitive with the private automobile.
- *central-city circulation:* provides fine-grain circulation along city streets and malleability in aligning routes, i.e., the ability to negotiate the tight curves of a grid network,
- *pedestrian compatibility*: slow speeds and responsive vehicle-braking make light rail vehicles hospitable additions to Karlsruhe's downtown pedestrian streets;
- *close station spacing:* lighter vehicles and exceptional braking allow for faster acceleration and deceleration, enabling stations to be placed closer together, thus shortening the access distances of suburban trip-makers; and
- *service penetration:* branch lines enable light rail to penetrate the cores of suburban communities, further reducing access distances.

While Karlsruhe is best known for its dual-mode track-sharing, seven distinct types of adaptive transit services are actually offered in the region, each involving some degree of resource-sharing and service integration. Table 6.1 reveals the rich variety of adaptive transit services that serve the region in 1997. The sharing of DB and city tram tracks using dual-voltage vehicles constitutes the lion's share of new, integrated services, with S-Train services extending to all quadrants of the region (Photo 6.3). These services are complemented by single-voltage light rail trains and trams that share active DB freight tracks. All but one S-Train line ties into Kaiserstrasse, Karlsruhe's main pedestrian-tram corridor and retail center. Spur lines also penetrate the cores of small towns and villages. In all, over 40 dual-voltage S-Train vehicles today combine with some 80 trams, 90 buses, and around a dozen inter-city DB-operated heavy rail trains to provide highly integrated regional services, serving towns as far as 40 km from downtown Karlsruhe. And since S-Train services tie directly to rail lines connecting into Heilbronn to the east, itself a hub of regional rail services, the spatial reach of Karlruhe's light rail services is effectively doubled along the north-east axis.

Functionally, Karlruhe's local and regional services involve a blend of three transit modes: trams (operating solely within the city on single voltage, thus not sharing heavy rail tracks); light rail (operating on dual voltage and sharing tram tracks in the city and heavy rail tracks outside the city); and heavy rail (operating solely outside the city on single voltage, thus not sharing tram tracks). And in terms of joint running of services, two forms exist: light rail and heavy rail on suburban tracks; and light rail and trams on city street tracks. It is Karlsruhe's light rail vehicles, then, that are the common and critical link in track sharing and the provision of integrated services.

6.7 Complementary Measures

Technology cannot claim sole credit for Karlsruhe's achievements. It was necessary to supplement hardware innovations with software support, namely the formation of a regional transit coordinating body and the introduction of downtown parking constraints.

A Verkehrsverbund, or transit federation, was formed to coordinate schedules and fares among transit operators in the region. The Karlsruher Verkehrsverbund (KVV), established about the same time dual-mode services began, does not itself provide services but rather contracts with the region's operating entities – the city tram operator (VBK), the regional S-Train and bus operator (AVG), the provider of inter-city heavy rail services (DB), and several private bus companies. A unique feature of Karlsruhe's Verkehrsverbund is that it oversees a rotating pool of qualified drivers, drawn from both AVG and DB, to operate S-Trains. S-Trains require specially trained drivers who can operate trains both at high speeds and in very slow-moving, unpredictable pedestrian settings. Versatile trains require versatile drivers. Driver pooling has proven particularly effective at reducing the amount of extraboard labor – that is, fewer back-up drivers are needed to cover unexpected absences. KVV also plays an important marketing role, symbolizing the integration of transit services within the region. All transit vehicles in greater Karlsruhe carry the KVV logo, even though different entities own and operate the vehicles. So far as the customer is concerned, there is but one regional transit network and the particular mode operating between point A and point B, be it tram, dual-mode LRT, or heavy-rail train, is of little relevance.

Table 6.1. Seven Types of Adaptive Rail Transit Services in Metropolitan Karlsruhe, as of 1997

Type of Service	*Lines (One-way kilometers, 1997)*
1 Track-sharing of DB lines with DB trains and city tram lines, with junctions connecting tram heavy rail networks	• Karlsruhe-Bretten-Eppingen *(54 km)* • Karlsruhe-Rastatt-Baden Baden *(30 km)* • Karlsruhe-Bruchsal *(16 km)* • Karlsruhe-Pforzheim *(22 km)* • Karlsruhe-Worth *(9 km)* • Ittersbach-Reichenbach *(31 km)*
2. Use of active DB freight track for non-dual-voltage (15000 volt ac only) LRT operations	• Bruchsal-Bretten *(11 km)*
3. Use of active DB freight track for non-dual-voltage (750 volt dc only) LRT operations	• Bad Herrenalb-Hochstetten *(43 km)*
4 Addition of a third track parallel to existing DB lines	• Grötzingen-Söllingen *(4 km)*
5 New LRT line through town center running parallel to existing DB line	• Durmersheim *(3 km)* • Stutensee *(2 km)* • Linkenheim *(3 km)*
6. Use of former DB lines by LRT with new tracks through town center	• Neureut *(1 km)* • Eggenstein-Leopoldshafen *(2 km)*
7 Conversion of non-DB freight lines to LRT	• Karlsruhe Hauptbahnhof *(1 km)* • Bruchsal-Menzingen/Odenheim *(29 km)*

Karlsruhe's integrated fare system is vital to providing integrated services. S-Trains, DB trains, bus services, and inner-city trams can be patronized using a single ticket. Environmental passes, educational passes, and one-day limitless ride tickets are the most popular forms of tariff payment, accounting for over 80 percent of all fare transactions. Combi-tickets are also used to tie fare payments to admission tickets of most major sports and entertainment events. Respectable transit services evidently succeed in getting passengers to respect the fare payment honor system -- fare evasion rates are very low, under 1.5 percent.

Parking policies have also lured customers to transit. Downtown parking is expensive and limited. There are no curbside spaces in the CBD Off-street parking garages, located on the edges of Karlsruhe's pedestrian zone, cost around US$3 per hour. Several parking garages have been torn down since the mid-1980s and replaced mostly by open spaces. Ludwig Square, a popular pedestrian zone in downtown Karlsruhe dotted with outdoor restaurants and cafes, was

Photo 6.3. S-Train Shares Tracks with a High-Speed Inter-City Train. A view of an on-coming DB high-speed train headed to Switzerland from inside an S-Train S-Trains operate up to 100 km per hour while sharing DB tracks, faster than the 75 km per hour they travel while on separate tracks in the suburbs

previously a 250-vehicle parking structure. Problems related to parking spilling over into residential neighborhoods have been avoided by requiring residential parking permits.

While official policy frowns on downtown parking, Karlsruhe's traffic engineers have made sure that whatever parking takes place does so in an efficient manner. An electronic parking management system guides motorists to the nearest vacant facility by the most direct route. Signposts show, in real time, the current number of vacant spaces in each parking structure. (Studies have shown that up to 15 percent of total downtown automobile traffic in German cities without such guidance systems consists of motorists searching for parking.)[10] By reducing the amount of cruising for parking, Karlsruhe's signpost system further contributes to creating a pedestrian- and cyclist-friendly downtown.

A totally different philosophy toward parking applies outside the central city. At suburban S-Train stations, park-and-ride lots are normally provided. Park-and-ride is viewed as an effective means of keeping cars out of the city and luring suburbanites into trains. It represents another example of adapting service provisions to the region's settlement pattern. While station-area parking is often viewed as a deterrent to transit-oriented development, since there is little direct policy interest in attracting growth to parcels surrounding suburban stations, in Karlsruhe, park-and-ride lots are viewed as assets, not liabilities.

6.8 Payoff

Recent transit ridership trends provide the best evidence that Karlsruhe's adaptive light rail services have made a difference. While transit patronage has fallen sharply in most medium-size

German cities since the mid-1980s[11], in greater Karlsruhe it has been on a steady upward ascent. Between 1985, when the idea of dual-mode transit and track-sharing was just taking form, and 1996, four years into the program, annual transit ridership more than doubled from 62.2 million trips to over 130 million trips. Presently, some 40 million annual trips, or around 30 percent of the regional total, are made on the S-Train. Surveys show that 38 percent of S-Train commuters are former drive-alone motorists and 22 percent previously carpooled to work.[12] Transit riding has particularly caught on within Karlsruhe city itself. In 1995, 263 transit trips were taken per resident – more than any other medium-size German city. Transit's growing popularity has helped put transit's fiscal house in order. In fiscal year 1995-96, KVV was able to recover 86 percent of operating costs through farebox receipts, one of the highest rates of return in Europe.

It was the initial experience with joint running of LRT and heavy-rail trains, along the Karlsruhe-Bretten corridor, that yielded the most impressive ridership results to date. The S-Train to Bretten, a quaint town of 13,000 inhabitants that dates back to medieval ages and which today is home to several thousand Karlsruhe workers, began service in September 1992. It replaced a short-haul DB heavy-rail service that required a transfer at Karlsruhe's main station, and because of more frequent service and faster average speeds, it reduced average commute times to the city by 20 minutes. Within the first week of the Bretten service, transit patronage along the corridor jumped by 600 percent, from 2,000 to 12,000 trips per day.[13] Transit went from 5.7 percent of all trips made by Bretten residents in 1991 (one year before) to 10.2 percent in 1993 (one year after).[14] For those working in Bretten, transit shares of work trips rose from 4.6 percent to 9.8 percent within the first six months of S-Train services.[15] A panel survey of 2,000 Bretten residents, conducted one year before and after S-Train services were introduced, found that over 80 percent felt transit services to Karlsruhe had substantially improved over this period.

Most of the credit for these stellar results goes to the superior service features of S-Trains. While the previous DB inter-city train tied into the peripherally located central station, requiring most customers to transfer to and pay an extra fare for trams, with the S-Train Bretten residents could go directly to the city center. Services were also intensified, operating at 20-minute headways, more frequently than the short-haul DB trains that were replaced. DB responded in kind by transferring resources, initiating a new semi-fast train service to Heilbronn using the same track. This further expanded transit options available to Bretten residents, to three regular-stop S-Trains per hour plus one to two skip-stop semi-fast trains per hour. Also important was the fact that S-Trains ran and continue to run more hours of the day, well past midnight, whereas the previous DB heavy rail trains stopped service at 7 p.m. Other contributing factors were the restructuring of feeder bus services to provide timed-transfer connections, the elimination of transfer fare penalties, the addition of more stations in Bretten itself (from one on the edge of town to seven spaced 300-400 meters apart), and a successful local campaign to create a more pedestrian- and cyclist-friendly village center. With the aid of a pro-active mayor and town council, Bretten phased in a series of measures that removed car traffic from the village center – some parking was eliminated, an internal bike path system was built, and streets were closed off to pedestrians. Today Bretten lays claim to being one of the smallest communities in Europe with a multi-street pedestrian zone, spanning over a kilometer in length. As a result of improvements in the walking environment, coupled with the addition of six new stations, three-quarters of Bretten train customers today reach a train station by foot.[16]

The impacts of innovative new rail services have been just as impressive in Karlsruhe city. Transit patronage among Karlsruhe residents tripled from 1988 to 1994, while the share of trips by private car drivers fell to just 14 percent over the same period.[17] Surveys show that 75 percent of Karlsruhe's citizens are "very satisfied" with their public transit services.[18] When headed to the city center, 40 percent of residents go by train. When making a shopping trip, the share is closer to 60 percent.

6.9 Lessons from Karlsruhe

Greater Karlsruhe has been exemplary in adapting transit technology to the regional landscape. There, transit seeks to follow and serve development rather than shape it Trains and buses connect the places where people want to go rather than trying to re-contour the places themselves.

In Karlsruhe, public transportation is taken seriously. Through visionary leadership and an entrepreneurial-like willingness to innovate and take risks, this medium-size region with high automobile ownership has managed to create a world-class transit system. Track-sharing has allowed the reach of transit services to expand at a fraction of the cost that would have been incurred laying new track. In greater Karlsruhe, one today finds villages of 5,000 inhabitants surrounded by rolling countryside yet served by multiple stations and S-Trains that come by every 20 minutes. Speedy, seamless, and reliable light rail services that minimize tedious changes of mode have paid off. Patronage is steadily rising. The commercial centers of Karlsruhe and its suburbs are today teeming with life. Transit has become the mobility choice of many city-dwellers as well as suburbanites and villagers.

The Karlsruhe approach cannot be cloned, nor is it suited for everywhere. Its experiences are probably most transferable to small-to-medium size areas where standard-gauge and electrified commuter passenger and freight tracks exist in the suburbs and exurbs that are not heavily used. If tracks are busy, there may not be the capacity to add light rail services. However, since many inter-city city rail lines cater to commuter markets or operate limited numbers of passenger runs per day, in many cases there is likely untapped track capacity, as in greater Karlsruhe.

The lessons from Karlsruhe are not limited just to technology and hardware. Karlsruhe's experiences underscore the importance of strategic planning – setting clear objectives, formulating and articulating a vision, advancing untested yet imaginative ideas, marketing these ideas to gain broad-based support, and perhaps most important, always keeping the target in view – namely, being responsive to customer needs and preferences. Karlsruhe also shows the value of resource conservation and exploiting opportunities when and where they avail themselves. The very premise of track-sharing was that it represented a way of providing high-quality and expanded transit services by making efficient use of available yet underutilized resources – in Karlsruhe's case, DB tracks. While federal officials remained leary about the safety of this venture, sufficient care and attention was given to the design of dual-system light rail vehicles to eventually overcome these concerns. To date, there have been no serious encounters or collisions between S-Trains and heavy-rail DB trains. Karlsruhe's exemplary track record demonstrates that the safety barriers to shared track transit services are not insurmountable.

If imitation is the highest form of flattery, then Karlsruhe is certainly the envy of many medium-sized cities of the world. Adopting the "Karlsruhe model", shared-track light rail services have recently been introduced in Saarbrücken and Kassel, Germany, and are seriously being considered in some 30 cities across Europe and as far away as New Zealand. Interest has been so great that a private company, TransportTechnologie-Consult Karlsruhe (TTK), has been formed to manage and market the knowledge transfer from Karlsruhe. If other places can successfully follow in Karlsruhe's footsteps, the future of adaptive light rail transit should be a bright one.

Notes

1. Source: Stadt Karlsruhe, *Verkehr in Karlsruhe: Daten zur Verkehrsentwicklung* (Karlsruhe: Stadt Karlsruhe, 1996).

2. For most medium-size German cities without metros, rail transit services are provided via two separate systems – the urban tram or LRT services, provided by municipalities, and the inter-city, regional railway services of the German Railway (DB). As a rule, DB passengers who want to reach the city center have to transfer to a tramway.

3. As far back as the 1960s, trams were run on unelectrified freight lines and abandoned railroad tracks in the region. The adoption of standard gauge tram vehicles allowed for this early track-sharing. These were not dual-propulsion services, however, since vehicles operated under a single-voltage electrical system.

4. Source: Karlsruher Verkehrsverbund (KVV), data files.

5. The maximum weight most urban roads can handle is 11 tons per axle

6. Joining in partnership with AVG to design and eventually build the hybrid rail cars was ABB (now Adtranz, Inc.) and Duwag (now merged into Siemens, Inc.).

7. For example, international trains must convert from 15,000 ac volts while in Germany to 25,000 ac when entering France and 3,000 volts dc when crossing Italy's borders. Designing such systems for locomotives was relatively easy because space was readily available. With light rail trains, where space is at a premium and weight is an important consideration, the design challenges were much greater.

8. The signatories of the agreement were the city of Karlsruhe, DB, the town of Bretten, and the administrative subregion (Landkreis)

9. Capital costs were apportioned among three tiers of government. Federal and state (Baden-Württemberg) grants covered 85 percent of capital facility costs. The city of Karlsruhe and communities along the shared-track corridors picked up the remaining 15 percent of costs. Rolling stock expenses were also borne by local governments.

10. Source: Orski, Livable Communities: Lessons from Abroad, *Innovation Briefs*, vol. 6, no. 4, 1995, p. 2

11. John Pucher and Christian Lefèvre *The Urban Transport Crisis in Europe and North America.* (Houndsmill, England: Macmillan Press, 1996).

12. Source. Verkehrsbetriebe Karlsruhe and Albatal-Verkehrs-Gesellschaft mbH, *Report 95* (Karlsruhe· VBK and ABG, 1996).

13. D Ludwig, Light Rail on DB AG Tracks, *RTR*, Vol. 36, 1994, pp 3-6.

14. Rail transit market shares rose from 4.2 percent to 7.2 percent over this two-year period.

15. Kommunalentwicklung, Baden-Wurttemberg, *Modellvorhaben Bretten* (Stuttgart· Kommunalentwicklung, 1995)

16 *Ibid*

17. Karlsruhe, Amt für Stadtentwicklung, *Daten Kakten Informationen, 1995, Karlsruher Statistik* (Karlsruhe· Amt fur Stadtentwicklung, 1996).

18. W. Wyse, Light Rail through the Valleys Karlsruhe's 'Product of the Year'£ *Light Rail and Modern Tramway*, Vol. 57, No. 683, 1994, pp 283-293

Chapter Seven

Guided Busways in a Small Metropolis: Adelaide, Australia

7.1 Synopsis

In South Australia's capital city of Adelaide, a new form of suburban transit service, the track-guided busway, has been in operation for over a decade. Called O-Bahn, the service is perfectly suited to greater Adelaide's low-density, auto-oriented landscape. Along the 12 km O-Bahn busway, guide rollers steer vehicles along a concrete track at speeds of up to 100 km per hour, providing safe, efficient, and fast services, partly because drivers can concentrate on optimizing speeds versus maneuvering the wheels. Once buses reach the city center, drivers take the helm, operating like regular buses. By combining feeder and line-haul functions in a single vehicle, O-Bahn services virtually eliminate the need to transfer. Providing door-to-door services from one's home to the CBD has been key in winning over customers to the O-Bahn. Ridership on the O-Bahn system has steadily increased despite a downturn in the local economy and eroding transit patronage outside of the O-Bahn's service area. Complementing the O-Bahn technology has been a series of environmentally friendly initiatives, most notably the integration of busway with a linear parkway and the introduction of Australia's largest fleet of buses propelled by compressed natural gas Also important have been moves to inject greater competition in Adelaide's public transport sector. The institutional separation of responsibilities for planning and overseeing transit services from the actual running of buses has also led to full fare integration, similar to what is currently found in Germany.

7.2 Transit in an Auto-Oriented Metropolis

On the whole, public transit can hardly be called a success in Adelaide, a metropolis of some 1.1 million inhabitants in an otherwise remote part of Australia. After all, transit today carries just 6 percent of all motorized trips in the region, fairly modest by non-American standards. Yet as a comparatively small metropolis that is striving to introduce innovative and cost-effective transit services, Adelaide stands out. As an example of a spread-out area that is earnestly trying to adapt transit technologies and services to handle dispersed travel, few places can match Adelaide. And in the spirit of addressing the challenges of making transit work in a small, remote region absent any serious traffic congestion, Adelaide makes an interesting case study.

Much of the credit for Adelaide's free-flowing traffic goes to its illustrious history of town planning The core city is laid out as a square-mile grid ringed by a greenbelt according to the specifications of William Light's 1839 Plan, well-known internationally, not the least because of its inclusion in Ebenezer Howard's celebrated work on Garden Cities. The center city, today home to some 16,000 residents (down from 50,000 in the early part of the century), is very distinctive, with stately Edwardian buildings and quaint Victorian homes laced with gracious iron work abutting modern office towers. Outside the inner greenbelt, the landscape takes on a contemporary, post-war appearance, with large-lot, detached development predominating. Hemmed in by the sea to the west and hills to the east, urbanization has occurred along a north-south axis some 80 km in length and 30 km in width, forming a linear metropolis that is today home to around a million inhabitants. Prominent is the region's neatly platted super-grid network of wide arterial streets. The combination of spread-out, low-density development and generous road capacity has dispersed trips and virtually eliminated traffic congestion, save for a few arteries entering the core during peak hours. Today, Adelaide prides itself as the "20-minute city" – one can seemingly go from anywhere to everywhere by car within 20 minutes. With some 500 cars per 1,000 residents and market-driven patterns of suburbanization, the region as a whole is unabashedly automobile-oriented. Against such odds, how does such a place win over motorists to transit? The answer is to offer a very attractive public transit option that, at least in part, mimics the door-to-door service features of the car.

Greater Adelaide's well-developed public transit network features a balance of train and bus services, augmented by a single aging tram line connecting the core to a beach-side suburb. Four heavy rail lines link outlying areas to the central city, functioning mainly as commuter railways. It is buses, however, that are the real workhorses of the public transport system, today carrying 82 percent of regional transit trips. Operated by three different transit companies under competitively awarded contracts, bus routes have been configured to provide a mix of local-feeder runs, intermediate-haul connections, and long-distance, mainline services. The region's most distinctive, and certainly most internationally renowned, mainline bus service is its track-guided busway (Photo 7.1). The guided busway and connecting feeders are superbly adapted to the area's suburban landscape, evidenced by their superior ridership performance relative to all transit services in the region. It is to the technology of track-guided bus services and Adelaide's cutting edge experiences with it that we now turn.

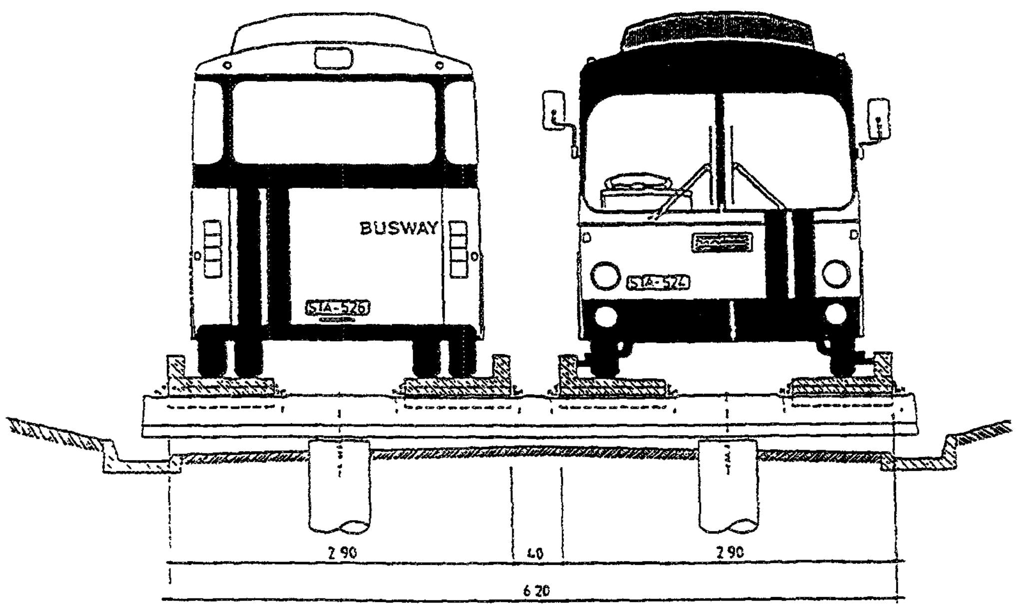
7.3 Adelaide's Track Guided Busway: The O-Bahn

Track guidance is a simple yet cost-effective approach toward blending the service features of a bus and rail service in one vehicle. Rollers directly connected to the steering knuckle of a bus guide the vehicle along a raised concrete track. The interaction of the guide rollers and track steers the bus (Figure 7.1). Designed by Daimler Benz AG and Ed Zublin AG and first introduced in Essen, Germany, the patented technology carries the name of O-Bahn. Track guidance allows buses to safely reach high speeds along mainline corridors, comparable to railway services. However, unlike rail cars, buses can leave the guideway, filtering into residential neighborhoods. This allows the same bus to function as a feeder and mainline carrier. And, of course, same-vehicle services virtually eliminate transfers, the scourge of suburban transit services worldwide. Today, Adelaide boasts the world's fastest and longest guided busway.

7.3.1 Why O-Bahn?

Why is it that a medium-size metropolis in a fairly remote part of Australia has taken on the mantle of O-Bahn as the future of suburban transit services? The answer lies largely in a

Photo 7.1. Adelaide's Track Guided Busway. A conventional coach equipped with roller guides is steered along a tree-lined busway corridor.



Source Passenger Transport Board, Adelaide

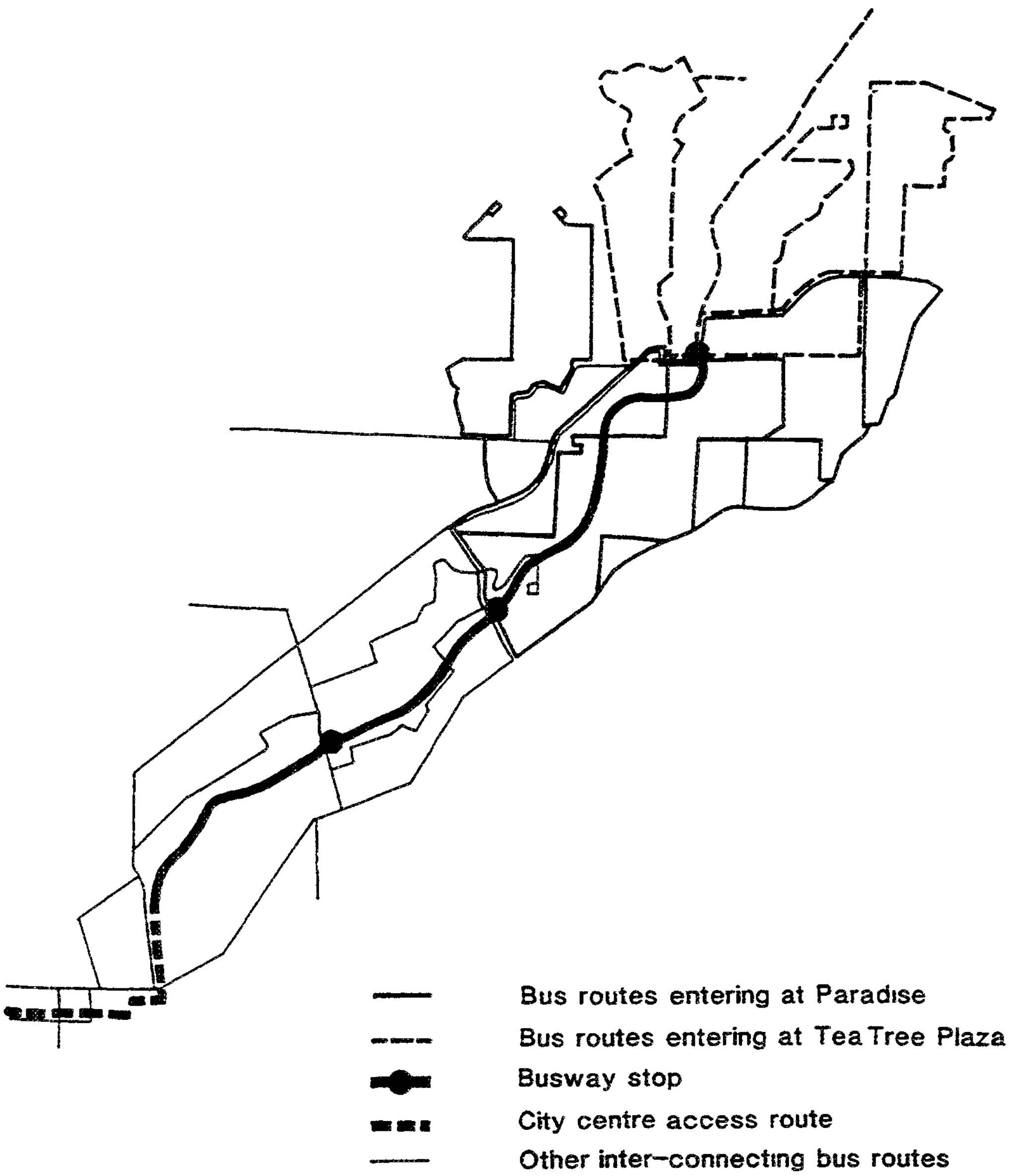
Figure 7.1. Typical Track-Guided Busway Cross-section. Guide rollers are fixed to rigid arms which are in turn connected to the front axle of the bus The rollers, functioning as horizontal stabilizers, interact with a raised concrete lip to automatically guide the vehicle, freeing the bus driver of steering duties. In Adelaide, the track consists of precast concrete elements assembled like a railroad track. Concrete cross beams are supported on bored piles to provide long-term stability. L-shaped concrete slabs atop the cross beams form the guidance surfaces. To handle Adelaide's high-speed bus services and provide a comfortable ride, a continuous and precisely fitted concrete surface was needed. Prefabrication was a prerequisite to achieve the required accuracy. Adelaide's busway tracks were constructed to tolerances of plus or minus 2 mm To achieve such precision required the introduction of rigid quality control procedures both at the manufacturing plant and during track assembly

confluence of events that made O-Bahn a natural choice for meeting the mobility needs of the region's comparatively fast-growing northeast corridor. During the 1960s, when the region was most rapidly suburbanizing, studies called for major freeway development to handle the growth in traffic, and public officials dutifully began preserving rights-of-way. However, by the 1970s, growing concerns over environmental quality and energy consumption led to a public backlash against the freeways, and none were built save for an interstate connecting the central city's edge to the hills and eastward. Yet with continuing growth in the northeast corridor, the only axis from the central city unserved by rail, it became increasingly evident that some form of high-capacity fixed-guideway service would have to be built. Surface-street buses were taking an hour or more to get from the outer reaches of the northeast suburbs to the city center. After extensive study, officials decided to go with a new light rail line. Light rail was preferred over a conventional busway because it would occupy less right-of-way, would emit less air pollution, and was perceived as being quieter and more comfortable to ride. Also, surveys revealed an overwhelming public preference for LRT services. As preliminary design work on LRT construction progressed, so did the estimated costs. Eventually, the projected cost of putting the CBD segment of the LRT underground proved to be prohibitive. By 1981, when city officials began to rather reluctantly reconsider building a conventional busway, a few local transit professionals had heard about a new German innovation, the O-Bahn, that combined operating features of a bus and a railway. A delegation from Adelaide quickly organized a trip to Germany to visit the O-Bahn test tracks in Stuttgart and witness the first field application in Essen. The group was immediately impressed by what it saw and reached quick consensus that the O-Bahn was the right technology for Adelaide's northeast corridor. After a follow-up economic analysis confirmed this, the decision was made to move forward with the O-Bahn technology.

The commitment to O-Bahn was a courageous choice, considering that no area, not even in Germany, had built anything comparable to what was planned for Adelaide.[1] However, among Adelaide's transit leaders, the choice was a prudent one. At a substantially lower capital cost than LRT, yet with a similar carrying capacity, it would incorporate the best features of LRT – safe, comfortable, and speedy mainline services – with the best features of a busway, notably the flexibility to leave the guideway and provide transfer-free connections between suburbia and the central city. Much of the capital cost savings would come from not having to build a CBD tunnel since buses could operate on Adelaide's spacious grid of downtown streets. Besides providing faster point-to-point services, track guidance was viewed as preferred to conventional busway because considerably less right-of-way would be needed along the northeast corridor's river valley alignment. Minimizing intrusion on the River Torrens and its sensitive surroundings was viewed as a high priority by all.

7.3.2 Adelaide's O-Bahn Services Today

The first stage of Adelaide's O-Bahn opened in 1986, and the full 12-km northeast corridor was in place by 1989 (Map 7.1). Today, buses from 18 different routes wind through residential streets in the northeast suburbs before entering the guideway at one of two possible access stations, what locals call "interchanges": the terminus at Tea Tree Gulley (15 km from the CBD) or the



Source: Passenger Transport Board, Adelaide

Map 7.1. Adelaide's Northeast O-Bahn Corridor. Eighteen bus routes feed into the mainline guided busway On average, 55 percent of the distance traversed is on normal suburban streets, 30 per cent is on the guideway, and 15 percent is on city streets

Paradise interchange (9 km out) (Photo 7.2). With steering completely controlled by the guideway, buses reach speeds of up to 100 km per hour on the fully grade-separated facility, stopping at a third station, Klengig (5 km out) if there is customer demand.[2] Unlike the other two stations, Klengig has no direct bus ingress-egress or park-and-ride facilities; all of its passengers are either walk-ons or arrive by bike or bus transfers. Upon reaching the outer edge of the CBD, vehicles leave the guideway and travel the remaining 3 km to the core on city streets like regular buses.

Having just three interchanges along the guideway has been crucial to instituting high-speed mainline services. It was possible to get by with fewer stops than would be required with light rail since bus transit can be a circulator-distributor as well as a line-haul carrier. That is, fewer stations were possible since, with buses, direct access does not depend solely on stations. Currently, 81 percent of O-Bahn patrons board buses at street stops, and the remaining 19 percent board at station interchanges.

A total of 110 O-Bahn buses, fitted with guide rollers, currently operate along the guideway, out of a total regional bus fleet of over 700. Most are articulated diesel buses.[3] During peak periods, individual buses operate on 10-15 minute intervals, resulting in an O-Bahn bus coming by, on average, every 53 seconds. Local officials maintain that O-Bahn buses can operate on intervals as short as 20 seconds apart, without expensive signaling equipment, because of the superior traction of rubber-tired vehicles, horizontal stabilization from guide wheels, and the advanced anti-lock braking systems and independent front suspensions on all O-Bahn buses. Extensive field tests show that from a 100-km-per-hour speed, O-Bahn buses can stop – quickly,

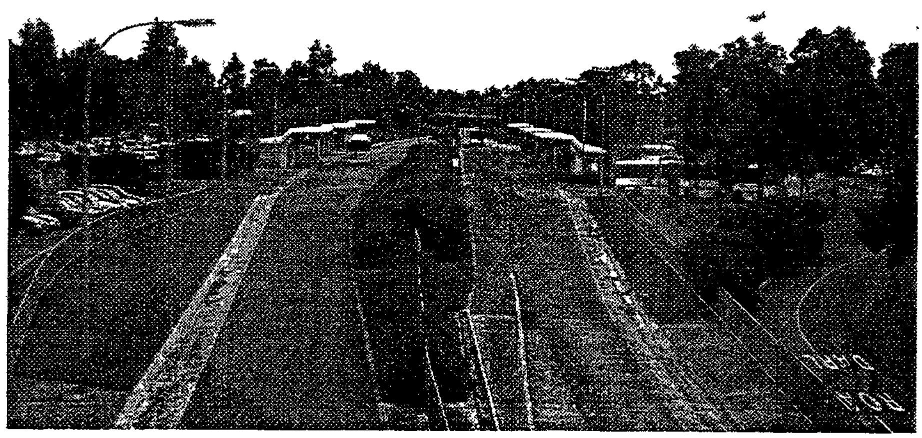


Photo 7.2. Paradise Interchange, O-Bahn's Intermediate Stop. An articulated bus, on the right, leaves the guideway as it converts from its line-haul to its feeder role. A bikepath, at the lower right of the photo, winds alongside the guideway and its tree-shrub parkland.

smoothly, and in a straight line – within two vehicle lengths. With such vehicle responsiveness and fleetfootedness, the O-Bahn can theoretically handle 18,000 passengers per hour in one direction.[4] This is in the ballpark of what most advanced LRTs can handle, and begins to approach the lower-bound capacities of older heavy rail systems. Currently, the O-Bahn averages 4,500 passengers per direction per peak hour, or just a quarter of theoretical throughput. With some 27,000 passengers currently traveling along the busway each weekday, local transit officials feel the current guideway could handle well over 150,000 daily trips, a volume that is many decades away given the region's fairly slow economic and population growth.

7.3.3 Environmental Mitigation

Adelaide's O-Bahn planners have gone the extra distance to make the O-Bahn an environmental-friendly addition to the local transit scene. Through the care taken in designing and integrating the busway into the surroundings, they overcame environmental concerns about impinging on the delicate Torren River valley. The O-Bahn alignment traverses along a riverbed made up of unsteady alluvial deposits. The extreme plasticity of soils required extraordinary engineering and design. O-Bahn's unique track system, with its precast track elements and sleepers resting on piers, proved to be highly adaptable to the unstable soil conditions.[5] Moreover, its relatively light weight put far less load on the river valley than the originally planned LRT alignment would have.

Prior to the arrival of the O-Bahn, the Torrens riverbed had become a neglected urban drain, littered with rubbish and inaccessible to the public. With the O-Bahn, landscape architects and planners saw an opportunity to transform the corridor into a healthy linear park. The corridor was attractively landscaped with berms, and the guideway itself was mostly depressed below surface to minimize noise impacts on surrounding residents. Walk paths and bikeways were aligned along the entire 12-kilometer stretch. Trees planted along the busway formed part of an "oxygen bank" in a novel "trees for transit" scheme that was introduced, part of Adelaide's continuing commitment to reduce the emission of greenhouse gases into the atmosphere. Because organic plants take in carbon dioxide as they grow and give out oxygen, a campaign has been under way to plant some 300,000 trees and large shrubs along the O-Bahn corridor to neutralize emissions from buses.

Another significant effort to become an environmentally friendly transit system has been the push to introduce CNG (compressed natural gas) buses. Currently, Adelaide has the largest CNG bus fleet in Australia – 110 of the region's 700-plus bus fleet are currently CNG vehicles, with plans to replace some 100 existing diesel buses with CNG by the year 2000. Because natural gas burns much more cleanly than liquid fossil fuels, does not emit diesel particulates, and generates much lower levels of nitrogen oxides and sulphur oxides, local environmentalists have actively lobbied for these conversions. CNG also makes good economic sense. Because of Australia's significant reserves of natural gas and its exemption of CNG from federal excise taxes, the cost of natural gas is significantly less than that of diesel. In that CBG involves additional capital costs, notably for pressurized on-vehicle tanks, special fuel discharging systems, and off-site compressor stations, fuel prices had to be significantly lower to justify the investment. In 1997, a liter of CNG cost around half as much as a liter of diesel fuel. Taking into account the slightly lower fuel efficiency of CNG, studies show that it still provides an estimated savings of around US$8,200 per year over diesel fuels (in 1997 dollars).[6] Experiences so far show CNG buses to be as reliable as the diesel fleet, with the added advantage of being more cost-efficient and environmentally friendly.

7.3.4 The O-Bahn Advantage

Adelaide's ten-year foray into the unchartered waters of mounting and sustaining O-Bahn services point to a number of clear advantages over alternative systems, notably light rail transit and conventional busway. By way of summary, these include:

- *Adaptability*: The O-Bahn's chief advantage is that is well-suited to the suburban milieu. Same-vehicle services virtually eliminate transfers. Adaptability also means that if a vehicle breaks down and blocks the track, buses can leave the guideway upstream, using regular surface streets to bypass the disabled vehicle.

- *Right-of-way Savings:* Because the O-Bahn's 6.2m-wide tracks are only a little (100 mm) wider than a bus, considerably less right-of-way was needed than for a busway, where vehicles are manually steered. This provided significant savings, particularly in tunnels, on bridges, and along areas requiring substantial earthwork and landscaping.

- *Cost Savings*: The avoidance of new capital expenses for depressing the CBD alignment and for advanced signaling systems resulted in a capital cost that was about half what a light rail system would have cost for the 12-km corridor. At US$6 million per km (in 1985 dollars), the guided busway cost only 12 percent more than a busway would have, in part because it required less right-of-way acquisition.

- *Lighter*. O-Bahn placed less deadweight load on the corridor's fragile riverbed corridor than would have a LRT line or a wider conventional busway.

- *Faster*: As an exclusive, grade-separated corridor, the guideway cut the time in half from getting to the city center from the northeast terminus – from 46 minutes on previous regular-stop bus services to 23 minutes on the O-Bahn.

- *Safer*: Exclusive segregation from other traffic, along with guided steering and the guideway's high-quality running surface, has increased passenger safety. Relieving drivers of steering duties and freeing them to concentrate on managing speeds and braking, if necessary, has reduced the chance of driver error in high-speed operations. Safety has also been enhanced by a back-up steel wheel system that allows vehicles to proceed along the busway at up to 50 km per hour in the event a tire suddenly deflates.

- *More comfortable*: Because guide rollers act as horizontal stabilizers and the precast concrete track was built to such fine tolerances, buses run very smoothly, providing a ride quality well above that of a normal busway.

- *Quieter:* Owing to the smoother running surface and the absorption of tire noise by the L-shaped guideway surface and surrounding berms, the O-Bahn provides a relatively quiet ride. Nearby residences are also spared from loud noise, less than what a busway or steel-on-steel railway would have generated.

- *Staging flexibility*: As with a busway, the O-Bahn provides staging advantages over rail systems. The guideway does not have to be continuous or built and opened in one fell swoop. Rather, it can be built incrementally in stages. Whereas railways need to go the full length, penetrating the CBD, to become operational, busways can commence services in pieces.

7.3.5 Ridership and Development Impacts

That Adelaide's O-Bahn technology is the right "fit" for the northeast corridor's spread-out landscape seems indisputable from ridership evidence. Between 1986/87 and 1995/96, annual patronage on the region's bus, rail, and tram system fell from 82.0 million to 62.9 million boardings, or by about 23 percent (Figure 7.2).[7] During the same period, ridership on the 18 bus routes using the guideway shot up by 75 percent, from 4.2 million to 7.4 million, an increase well in excess of the 18 percent growth rate in the busway's prime catchment area. Moreover, while the region's transit modal split was just 7 percent of all trips in 1991, for radial journeys along the northeast corridor to the city center, transit captured a 42 percent market share.[8] In real dollar terms, operating costs per boarding fell by 27 percent during the first seven years of O-Bahn operations, while rising 5 percent for all bus transit services operating within the region.[9]

Cross-system comparisons are also revealing. Between 1986 and 1996, ridership on the O-Bahn increased three times faster than ridership on the region's other mainline transit connector -- the commuter railways serving the northwest, southwest, and southeast corridors. The O-Bahn's "guideway effectiveness" is also nearly ten times higher than that of the railways, handling around 670,000 versus 69,000 passengers per route km per year. And "vehicle effectiveness" is far higher as well -- over the 1984/85 to 1991/92 period, boardings per vehicle kilometer rose 36 percent along the northeast corridor while falling 14 percent along railway lines.[10] These differences underscore the superior match of O-Bahn to the cityscape. Railways rely in good part on concentrated development around stations, which really has not occurred along suburban corridors. O-Bahn, on the other hand, accepts and works with low-density development, providing near transfer-free door-to-door services.

Who is patronizing O-Bahn? During peak hours, riders are predominantly workers and students heading to the city center, producing a directionally biased, tidal pattern of patronage. Surveys show that some 40 percent of new passengers during commute hours previously drove their cars to work.[11] During the O-Bahn's first five years of service, the greatest ridership growth actually occurred in discretionary trips headed to the CBD during the midday, mainly for shopping purposes. Besides receiving transfer-free services, surveys reveal midday, discretionary trip-makers are attracted by the pleasant views of the corridor's riverscape and the safety of the guided, segregated track. The most frequently cited benefit of the O-Bahn is its convenience.[12]

While the very premise of building an O-Bahn was to adapt to rather than reshape the suburban landscape, it is noteworthy that some degree of clustered, station-area development has occurred, the joint product of regional planning and market forces. For several decades, the busway's terminus, Tea Tree Gully, has been designated as one of five regional town centers. The region's latest *Planning Strategy* continues the commitment to directing future suburban growth along high-capacity transit axes, including the northeast O-Bahn corridor.[13] To date, the O-Bahn appears to have accelerated the conversion of Tea Tree Gully from a somewhat sterile new town designed around a regional shopping mall to an emerging urban village featuring a wide range of land uses. In the early 1990s, the site of a new regional college campus was relocated adjacent to the terminal station to take advantage of the parcel's superb access to the CBD. A medical complex has also sprung up nearby. Tea Tree Gully's shopping mall is presently being expanded atop existing surface parking in the direction of the busway terminus. Around the two other O-Bahn interchanges, local residents want nothing to do with transit-oriented development, however. They remain adamant that the surrounding neighborhood remain exclusively low-density residential. In fact, a recent request to open a small retail kiosk at the Paradise interchange was denied by the local council on the grounds that any commercial use was incompatable with the neighbor

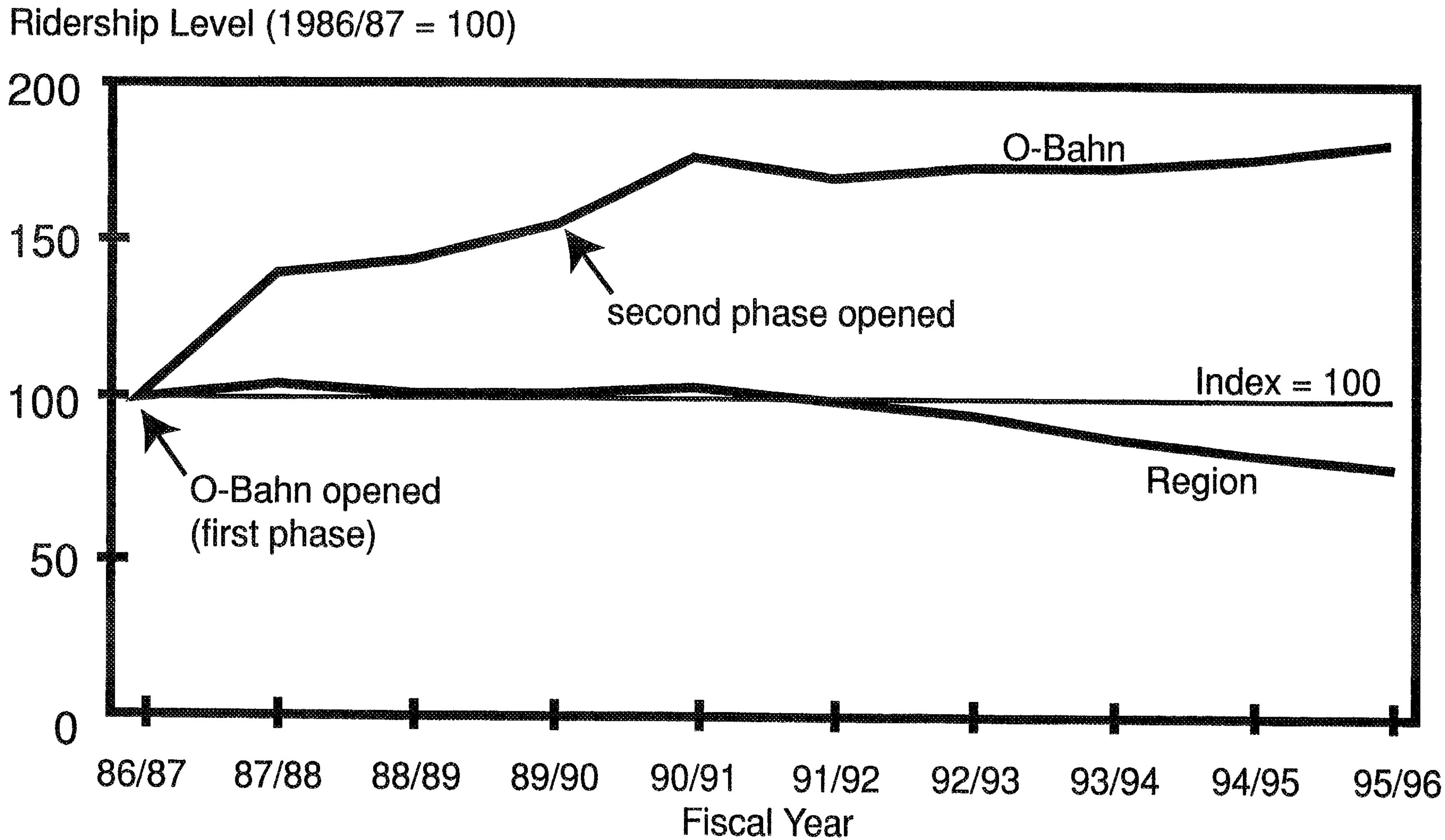


Figure 7.2. Comparison of Transit Ridership Trends Between the O-Bahn and the Region At-Large

hood's character. With such a mindset firmly rooted in Adelaide's suburbs, an O-Bahn system geared to serving low-density residences seems all the more appropriate for the northeast corridor.

7.4 Competitive Transit

While the O-Bahn remains Adelaide's claim to fame in the transit world, the region has also won kudos for injecting competition into the local transit arena. Triggering the move to a competitive transit marketplace were a series of institutional reforms introduced in mid-1994. Chief among these was a move to separate the policy and regulatory functions of transit services from the operations function. Borrowing a chapter from Germany, asset ownership and service oversight became the purview of the public sector while service delivery was opened to market competition, with the lowest bidders granted the rights to operate within contract areas, subject to meeting minimum service standards.[14] A new authority, the Passenger Transport Board (PTB), was formed by the South Australian government to oversee all rail and bus services within greater Adelaide. As the region's policy and regulatory body, PTB plans, regulates, and funds all land-based passenger transport in South Australia, which includes taxi and paratransit services in addition to buses and rail.

In 1995, PTB began tendering competitive bids for operating bus services within the region. Contracts were introduced in phases over the next two years. TransAdelaide, which formerly operated all bus services as the State Transportation Authority, won the contract for the southern sector of the region, while a private firm, Servco, was awarded the franchise for serving the northern sector. A much smaller concession went to Hills Transit to serve some suburban and rural communities in the far eastern suburbs.

The impact of competitive contracting was immediate. Within the first year, transit ridership increased by 2.5 percent on contract routes, compared to a 1.7 percent decline for the metropolitan area as a whole. Competition also served to contain wage rate increases and spawn staff reductions. Moreover, it resulted in featherbedding clauses being removed from labor agreements, allowing transit managers to assign drivers clerical and minor mechanical duties during slack periods. The combination of ridership gains on contracted routes and cost containment resulted in an increase in the region's cost recovery rate from 26 percent to 29 percent during the 1995/96 fiscal year.

From the user's perspective, perhaps the biggest benefit of institutional reform has been the emergence of an integrated fare system, also akin to that found in Germany. Now the same ticket can be used to hop on a tram or train and transfer to the O-Bahn. Similar to Germany's Verkehrsverbunds, Adelaide's PTB pools all farebox receipts and guarantees each operator a certain payment depending on the kilometers of services delivered. Institutional reform has also led to a more efficient fare structure. As an incentive to midday riding, 40 percent discounts are given during the interpeak (9 a.m. to 3 p.m.). Fares also reflect distance traveled, costing almost twice as much for journeys over three kms versus under three kms. Customer loyalty is rewarded through price incentives. A one-day, limitless-ride ticket goes for about US$3.60. Most popular is the multi-ride book, which for around US$12 provides 10 tickets, any one of which can be used multiple times within a two-hour time window.

7.5 Lessons from Adelaide

Adelaide's O-Bahn has proven to be a sensible choice for serving low-density, auto-oriented markets. By blending the speed and safety of light rail transit with the inherent flexibility and efficiencies of bus transit, the O-Bahn system has won over legions of loyal customers Ridership continues to increase, even though regional transit patronage has fallen.

Despite the success of Adelaide's O-Bahn, guided busways have not been widely adopted Apart from the slower-speed, shorter-distance O-Bahns now operating in Essen and Mannheim, Germany, there is no other similar system. This is a bit perplexing given some the inherent advantages of O-Bahn – comparatively low capital outlays, single-vehicle operations that reduce transfering, and a high-quality, smooth ride, among others. Adelaide's transit leaders seem particularly puzzled that no other city has copied the concept so far. City officials had hoped to cash in on Adelaide's pioneering success with the O-Bahn, expecting money was to be made in transferring its operating experiences and technical know-how to other places. A slick, nicely produced video, *Adelaide O-Bahn: The Innovative Solution*, warmly offers to build an Adelaide-style O-Bahn under a turnkey arrangement in any city that is interested.[15] Despite a constant parade of transit officials who come from around the world to witness Adelaide's O-Bahn firsthand, so far there have been no takers.

The reluctance to make the huge leap from curious observer to O-Bahn implementer likely reflects, in part, the second-class image problems that continue to plague bus transit. Whether rightly or wrongly, light rail transit is still widely perceived as a more modern, higher class of service more in tune with the times. Evidently, elected officials see more political capital to be gained from laying rail tracks than paving busways. Of course, some outsiders cast suspicion in the failure of Adelaide itself to expand O-Bahn services beyond the inaugural corridor. While this is mainly due to the region's slow population growth and economic woes, the inability to expand O-Bahn services has no doubt hurt its promotional cause.[16] A new high-capacity service to the south, from Adelaide to Darlington, is currently being studied, with O-Bahn one of several options under consideration. And from time to time there has been talk of replacing existing rail lines with guided busways. In the mean time, Adelaide continues to make headway in fine-tuning bus services and upgrading transit's image. The ambitious campaign to convert the bus fleet from diesel to CNG propulsion has won public praise. Less noticeable but equally important have been on-going efforts to refine bus services – altering a route here, adding more park-and-ride spaces there – along the northeast corridor.

As a radial line-haul connector to the CBD, O-Bahn's future will hinge, in part, on maintaining a strong, viable center. While the suburbanization of residences is inevitable, local planning officials recognize that a dominant center must be maintained if transit is to effectively compete with the private automobile. Historically, Adelaide's square-mile CBD has been the center of action. In 1991, the latest year for which data are available, 21 percent of regional jobs and 13.5 percent of regional retail sales were in the CBD; the retail share was higher than in any other Australian metropolitan area.[17] As elsewhere, these shares have no doubt slipped in recent years. In the case of retail, the recent closing of several large central-city department stores has alarmed CBD interests, though this had more to do with organizational restructuring within Australia's retail industry than with a decline in CBD business. While long-range planning controls guarantee that Adelaide's CBD will continue in its role as the pre-eminent commercial center for decades to come, the emergence of new second-tier centers has already sparked some discussions into what would become another Adelaide first, the opening of a cross-town O-Bahn corridor linking Tea Tree Gully to Port Adelaide to the east. If such a link ever gets built, it will continue Adelaide's proud tradition of pioneering new forms of adaptive suburban transit services.

Notes

1. Essen's O-Bahn service, introduced in 1981, operates mainly at surface in the median strip of a freeway (Autobahn), with guideway buses running much slower and stopping more frequently than in Adelaide. The most unique feature of Essen's original O-Bahn service was its dual propulsion. While operating in a CBD tunnel and along the freeway corridor, buses were electrically propelled The notion was that electricity would be more energy efficient for mainline services, and would avoid the problems of recirculating diesel fumes in the CBD tunnel Diesel propulsion was considered superior for stop-and-go conditions on regular surface streets when buses left the guideway However, because of technical problems and excessive cost overruns, Essen eventually eliminated the electrical component of O-Bahn operations, did away with its underground tunnel, and converted to pure diesel track-guided bus services outside the CBD.

2. Two of the bus routes serving the far outreaches of the northeast corridor operate non-stop along the guided busway.

3. While Adelaide's O-Bahn relies on diesel-powered buses, the system was designed for conversion to electrical traction if and when petroleum fuel prices rise high enough to justify it.

4. This assumes an average of 100 passengers per bus and 180 bus runs per direction per hour (e.g., 20 seconds between buses).

5. H Sack, The O-Bahn Guideway, Adelaide· Technical Constraints and Challenges, *Guided Busway Transit: Proceedings of the International Seminar* (Adelaide Sagric International, 1989, pp 11-13).

6 This assumes a price of US$0.51 per liter for diesel versus US$0 22 per liter for CNG. Adjusting for differences in fuel efficiency results in an average diesel cost of US$0.21 per km compared to US$0.11 per kilometer for natural gas, assuming buses travel 60,000 km per year. Source H. Ng, Adelaide's Clean Public Transport (Adelaide: Passenger Transport Board, staff paper, 1996)

7. Data were compiled from annual reports provided by the Passenger Transport Board, including Passenger Transport Board, *Annual Report 1995/1996* (Adelaide Passenger Transport Board, 1996). Also see· J Brown, Adelaide's Guided Busway Popular with Passengers, *The Urban Transport Industries Report*, Vol. 1 (Hong Kong· Campden Publications, Ltd., 1993, pp 58-59)

8. Sources: Regional travel surveys and census statistics from: Australian Bureau of Statistics, *1991 Census Journey to Work* (Canberra: Australian Bureau of Statistics, 1992). Surveys show that the first seven years of O-Bahn service, from 1986 to 1993, transit's modal share of work trips held steady in the 10 to 11 percent range. For 1986 modal split data, see Pak-Poy & Kneebone Pty. Ltd., *Transport Planning Model Development Study* (Adelaide: Department of Transport, 1990). For 1993 modal split data, see P. Gardner, *Drivers and Passengers· Travel to Work* (Adelaide. Australian Bureau of Statistics, Adelaide Statistical Division, Catalogue No 9203.4, 1993)

9. Cost recovery rates for buses operating in the northeast corridor increased from 24 5 percent in 1985/86, just before O-Bahn services commenced, to 38.3 percent in 1991/92, five years into the project For all bus services in the region, they increased only from 29 percent to 29.8 percent over the same period. Source· State Transport Authority, *Performance Indicators Report; 1984/85 - 1991/92: Eight Year Time Series* (Adelaide: State Transport Authority, Strategic Services Branch, 1992).

10. *Ibid.*

11. P. Chapman, The Adelaide O-Bahn. How Good in Practice?, *Australasian Transport Research Forum,* Vol 17, Part 1, 1992, pp. 83-100.

12. Denis Johnston and Associates Pty Ltd., *Northeast Busway Before and After Study, Final Report. Evaluation of the Busway* (Adelaide. State Transport Authority and Department of Transport, 1988).

13. With regional population growth at under 1 percent annually, the plan commits to efficiently managing change as the region gradually transforms from a single-center to a multi-centered metropolis. The long-range plan seeks to shift the balance of future urban development to the northern suburbs, away from the vulnerable vineyards to the south and hillscapes to the east. It also strongly commits to urban consolidation and infill development, though it recognizes that single-family housing remains a strong market preference and attempts to plan for it accordingly. The plan calls for giving development preference to regional town centers that are well-served by public transport. This bodes favorably for Tea Tree Gulley since it receives more intensive transit services than any. See Department of Housing and Urban Development, *Planning Strategy· Metropolitan Adelaide* (Adelaide· Department of Housing and Urban Development, State government of South Australia, 1997).

14. All assets, including depots, buses, trains, and the O-Bahn system itself, became the property of the state's Department of Transport. Besides asset ownership, the Department of Transport is responsible for planning, building, and maintaining all highways and roads within South Australia

15. Passenger Transport Board, *Adelaide O-Bahn: The Innovative Solution* (Adelaide, Kensington Studios and the Passenger Transport Board, 1996)

16. The reluctance to move foreward with additional O-Bahn lines seems also related to the release of a controversial study that found that, upon extending full capital costs and ridership projections over a 30-year period, the O-Bahn would yield a negative economic rate of return: a net present value of -US$37.45 million or a Benefit/Cost Ratio of 0.77. The projected loss was attributable mainly to the cumulative increase in access time (i.e., walking and waiting) for those converting from automobile to O-Bahn travel as well as the conclusion that the O-Bahn had little effects on traffic volume flows. It is this latter assumption that has drawn the most criticism, especially among environmentalist who contend that the study grossly underestimated the external benefits, such as reduced energy consumption, produced by the O-Bahn. Clearly, the O-Bahn project has not been immune to criticism or the fairly common disagreements between economists and environmentalists about the net worth of mass transportation systems. See Department of Transport, *An Economic Evaluation of the Northeast Busway in Adelaide* (Adelaide: Department of Transport, the Government of South Australia, 1991), and Chapman, *op cit.*, 1992.

17. R. Bunker and A. Tuttle, *The Role and Function of the Adelaide Central Area: Prospects and Trends* (Adelaide: Municipality of Adelaide, A Core Paper prepared for Adelaide 21, 1996); P Mees, 'The Report of My Death is an Exaggeration'", Central City Retailing in Melbourne Since 1900, *Urban Policy and Research* Vol. 11, No. 1, 1993, p 28.

PART THREE

SMALL-VEHICLE SERVICE REFORMS

Part Three examines experiences in four case-study areas where the focus of adaptive transit improvements has been on small-vehicle service reforms, including shuttles, route-deviation, general-public dial-a-ride, and jitney services: (1) Albany, New York; (2) Winnepeg, Canada; (3) Kansas City, Missouri; and (4) Mexico City, Mexico, and San Juan, Puerto Rico.

Chapter Eight

Flexibly-Routed Shuttles: Albany, New York

8.1 Synopsis

A new set of shuttle services has given workers in the Albany, New York, region a new measure of flexibility and a sensible way to access jobs. The region has many developing areas of dispersed, suburban-style employment which are outside the transit authority's normal service area and difficult to serve with traditional transit. Employers have chosen work sites based on factors other than accessibility, which has led to increased auto usage and made it difficult for many workers, especially transit-dependent ones, to get and keep jobs. The Capital District Transportation Authority's ShuttleBug, ShuttleBee, and ShuttleFly routes provide convenient, flexible service to these areas. By providing timed transfers from main fixed-route service to flexibly-routed shuttle/circulator services, the systems have gained loyal riders and very high approval ratings, as well as providing critical job access. And by creatively seeking funding for these routes, the agency has been able to add the new services while maintaining existing service

8.2 Employment Growth at the Periphery

The Capital District Transportation Authority (CDTA) serves the Albany, New York, area, which consists of the cities of Albany, Schenectady, and Troy. Its service area encompasses 150 square miles and a population of 780,000 persons.[1] While Albany is New York's capital city and therefore home to many state offices, the area's economy is fairly diverse. Like most areas in the U.S., the region has experienced a movement of employment to suburban sites, and by 1990 employment outside the region's central cities exceeded that within them. This trend has reduced job accessibility as well as transit ridership. Commuting by transit in the area decreased 16 percent between 1970 and 1990.[2]

At the same time, because the region has experienced little congestion,[3] there has been little interest in mobility alternatives to automobile travel. Air quality and job access have also not been high priorities, yet were being worsened by spread-out, auto-oriented growth. The CDTA's decision-makers sensed a growing obligation to improve services to suburban areas, especially in light of the increasing needs of lower income inner-city residents to access jobs.

8.3 Connecting to Employment

In 1996, CDTA initiated a shuttle program called ShuttleBug at an employment center on the urban periphery. The shuttle sought to demonstrate the value of better linking fixed-route main-line service with outlying job sites. The agency funded the experimental service by applying for and receiving a CMAQ grant.[4] Happy with the performance of the initial route, CDTA initiated two new routes, called ShuttleBee and ShuttleFly, in similar areas in 1998.

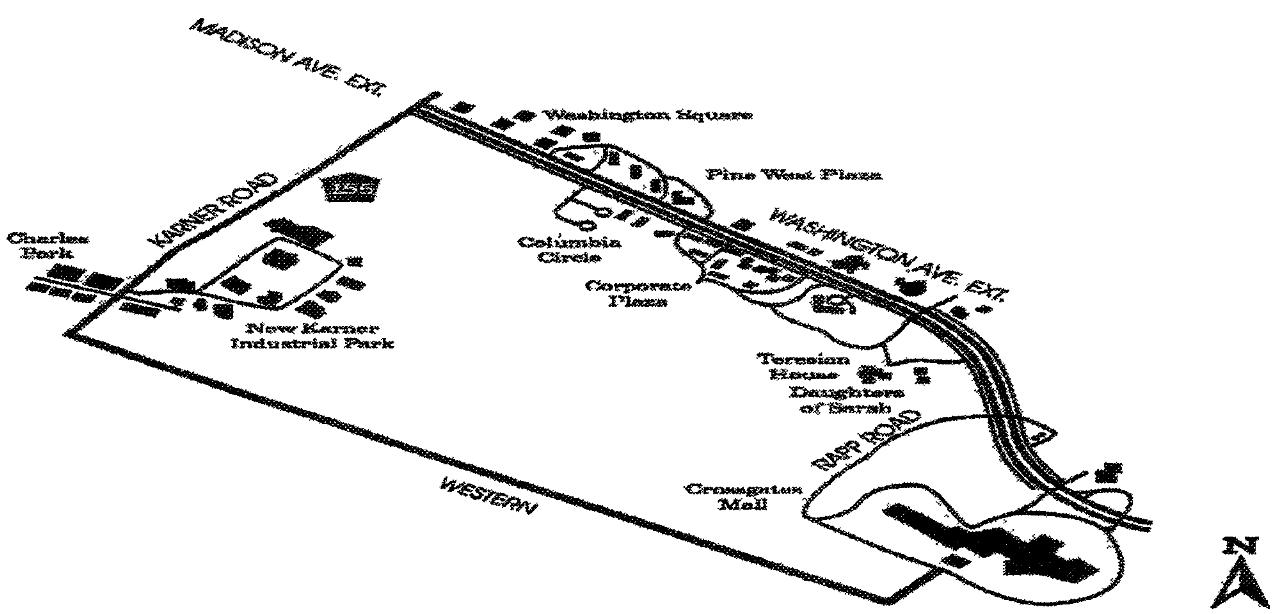
8.3.1 Three Similar But Distinct Services

The three shuttles serve large employment areas with somewhat different land-use characteristics and ridership markets, although they share in common an autocentric landscape: wide building setbacks, few sidewalks, and abundant free parking. CDTA targeted all three shuttles at commute trips, but one of the routes, ShuttleBee, serves mainly internal trips, making it something of a combination between a shuttle and a circulator. The other two shuttles, with their strong focuses on transfer centers and access to and from the larger area, operate to some degree as many-to-one dial-a-rides. The shuttle routes did not replace disabled paratransit services, provided by the STAR system (Special Transit Available by Request)

8.3.2 ShuttleBug

ShuttleBug, the original service, operates within the Crossgates Mall/Washington Avenue Extension/New Karner Road area, a busy employment center northwest of downtown Albany (Figure 8.1). Over 5,000 people are employed in the area in dispersed, low-rise complexes, served by a discontinuous street system with few sidewalks. It has proven to be a difficult area to serve with conventional fixed-route transit.

The ShuttleBug route originates at the Crossgates Transit Center, located at the Crossgates Mall (Photo 8.1). During morning and evening rush hours, the service runs on approximately 20-minute headways. Runs are timed in the morning and evening to meet three fixed bus routes at the center. During the midday, ShuttleBug runs approximately every hour. ShuttleBug totals 20 hours



Source: Capital District Transportation Authority; effective 21 November 1997

Figure 8.1. ShuttleBug map. The ShuttleBug connects a number of activity centers – the Crossgates Mall, New Karner Industrial park, and Corporate Plaza.

Photo 8.1. Crossgates Transit Center. This center is located in the parking lot of the Crossgates Mall. A ShuttleBug bus is in front, and a regular fixed route bus is to the rear. The center has a shelter as well as signage explaining ShuttleBug service.

of revenue service per day, including two hours added in 1998 to serve an area business's shift change.[5] ShuttleBug is free, and users pay regular fares if transferring to other CDTA routes.[6]

The institution of ShuttleBug required a few minor schedule modifications to other routes to aid timed transfers. The agency adjusted the shuttle's schedule to serve the starts and ends of shifts for employers in the area. CDTA also eliminated a portion of one fixed route so that it would not overlap with ShuttleBug services. This was done about six months after the initiation of ShuttleBug service, and forced a few people to make transfers who did not have to before.

ShuttleBug initially followed a fixed route. After six months of service, however, driver feedback led CDTA to convert to flexible routing. On the way away from the transfer center, the ShuttleBug simply takes people where they ask. On the way toward the transfer center, the ShuttleBug runs a basic route with regular stops, but also takes workers directly to their buildings and picks them up there as well. The area's arrangement of office buildings requires the bus to go through parking lots. In the mornings, when workers are heading to their jobs, the ShuttleBug operates only away from the transfer center, concentrating on outbound trips. A rider may, however, arrange to be picked up on request if he or she requires inbound transportation.

8.3.3 Expanding the System: ShuttleBee and ShuttleFly

Based on the positive response to ShuttleBug, ShuttleBee was introduced to serve a rapidly developing employment area along the Route 4 corridor to the east of Albany. The route has northern and southern segments centered on a CDTA park-and-ride lot at which ShuttleBee makes connections to two fixed bus routes (timed during rush hours). The shuttle deviates up to 3/8 mile off the normal route to serve the area's employers.

Employment in the area is currently around 5,000, and is expected to double in the next decade.[7] Employment types in the area are also expected to shift; one business park that currently employs many highly-paid high-tech workers appears likely to get manufacturing facilities with about 4,000 jobs. These workers are likely to be lower-paid and more transit-dependent than many of the current workers. Some housing is also planned for the area. Because of these expected changes, the agency has not yet determined the permanent alignment of the route and its stops. At present the shuttle runs along Route 4, and returns to Route 4 at the same points from which it left after deviations.

During the morning and evening rush hours, ShuttleBee operates one bus on each end of the route on 30-minute headways. During the midday ShuttleBee operates with one bus serving both ends of the route, also on 30-minute headways. Each workday, ShuttleBee operates for a total of 20 revenue hours.[8] ShuttleBee costs 25 cents to ride, though it is free with a transfer or a Swiper Card. Users pay regular fares if transferring to other CDTA routes.

The newest shuttle, ShuttleFly (so named because of its stop at the region's airport), serves the mixed commercial Wolf Road/Albany International Airport corridor north of Albany (Photo 8.2). It connects to several other routes, as well as the Colonie Center shopping mall. Along the ShuttleFly route are numerous offices, hotels, retail shops, and restaurants. It serves the largest employment center of the three shuttle routes, with about 15,000 workers.

ShuttleFly operates on 20-minute headways during the morning and evening rush hours and has coordinated connections to four fixed routes. During the midday, it operates on 30-minute headways. The CDTA did not immediately set ShuttleFly's permanent schedule so that it could be based on passengers' observed origin and destination patterns. ShuttleFly operates with time points at the Colonie Center, the airport, and an office complex on the northern end of the route.

Unlike the other Shuttle services, ShuttleFly also operates on Saturdays, from 7 a.m. to 7 p.m. at 30-minute headways. ShuttleFly operates four weekday peak and two midday buses for a total of 39 service hours per weekday. Its two Saturday buses operate a total of 25 hours.[9] ShuttleFly costs 25 cents to ride, though it is free with a transfer or a Swiper Card. Users pay regular fares if transferring to other CDTA routes.

Like ShuttleBee, after making a route deviation, ShuttleFly returns to the basic route at the point of departure. Several fixed bus routes also operate along portions of the same streets plied by ShuttleFly, and the shuttle serves these stops as well. When behind schedule, the shuttle may drop a passenger at a regular stop instead of the desired destination, or the driver may radio the dispatcher to have another bus do the pickup.

Photo 8.2. ShuttleFly on Wolf Road. This corridor has a variety of uses, mostly auto-oriented and surrounded by parking. In addition to dispersed uses, portions of Wolf Road lack basic pedestrian amenities such as sidewalks.

8.3.4 Shuttle Access and Deviations

A rider may access the three shuttles at designated stops or by having a shuttle deviate to his or her location. A rider calls the dispatcher to schedule a deviation, and there is no preset call-ahead requirement. Some passengers arrange deviation pickups for later in the same day while boarding the bus in the morning. In that case, the driver logs the pickup request and gives the information to the next driver over a shift change, or to another bus via the dispatcher if the pickup request would fall most conveniently into another shuttle's scheduled run. Similarly, for a drop-off deviation, a passenger may call the dispatcher or may simply request the deviation with the driver when boarding the shuttle.

8.4 Marketing

CDTA actively promotes the shuttle services and uses business and employee contacts to improve the service design. The agency created a new paint scheme to give the shuttles a distinct identity (see Photo 8.1). The agency directly markets the service through employee information days staged at businesses and offers complementary passes to get new employees riding transit.

CDTA markets its specialized suburban services as a package, emphasizing the availability of not only the shuttles themselves, but also a guaranteed ride-home program, employee information services, and monthly passes.[10]

8.4.1 Business Outreach

CDTA attempts to involve service-area businesses during both the system design phase and in promoting the shuttles. In designing shuttle routes, the agency places emphasis on serving employer shift changes and on meeting connections with mainline routes. For instance, a new run was added at the beginning of the ShuttleBee service period so that area employees beginning work at 7:00 a.m. could use the service. The agency also makes efforts to serve new businesses from their opening date if possible, so that transit-dependent persons will have a chance to get jobs there.

During the shuttle route planning phase, CDTA studies the major employers and physical characteristics in a corridor. Information gathered includes business locations, contact persons, numbers of potential riders (employees, students, residents, etc.), demand characteristics (e.g. periods of peak demand, trip origins), and physical characteristics of waiting areas and sidewalks. The agency then works to accommodate the distinct needs and characteristics of the area in the service design.

Employers participating in the CDTA Corporate program receive group discounts on bus passes for their employees. CDTA makes available promotional materials about the Shuttle services, helps employers design employee travel surveys, stages information days, and works to improve the walking environment and shelters within the corridors.[11]

8.5 Labor Issues

In an effort to control costs, CDTA competitively contracted operation of the ShuttleBug service to an outside company. CDTA opted to operate the newer ShuttleBee and ShuttleFly routes in-house. Still, the agency was able to control costs by negotiating a special driver-pay structure. The normal "system 1" pay rate is higher and applies to regular full-time drivers of large buses. The lower "system 2" rate, which shuttle drivers receive and which does not exceed 70 percent of the top rate, normally applies to STAR drivers and part-time drivers (all CDTA drivers begin as part-timers).

Shuttle drivers receive about one hour of training in addition to three weeks of basic training and two weeks of STAR training. STAR training prepares drivers for route deviation requests and map-reading. The drivers on the contracted route also complete CDTA training. CDTA employees perform dispatch functions for all shuttles, including ShuttleBug.

8.6 Complementary Measures

In addition to the shuttle routes, CDTA has implemented a variety of supportive programs to improve services to the area's suburbs.

8.6.1 Guaranteed Ride Home

The agency operates a guaranteed ride-home system for holders of CDTA bus passes. On request, the agency will arrange and pay for a taxi for customers in an emergency situation or who miss the last shuttle of the day. Annual individual use of the guaranteed ride-home system is limited. However, the system normally serves only as a safety net and is rarely used. In over three years of program operation, the agency has yet to spend its entire $40,000 annual budget for the service.

8.6.2 Tangential Route – The Four Mall Circuit

Most of the CDTA's route structure follows old trolley lines, forming a generally radial system focused on the traditional core. CDTA's Route 17 was introduced to better serve new suburban activity centers. Initiated in 1998, this cross-town route supplanted a previous more traditionally-oriented service. Known as the "Four Mall Circuit," Route 17 serves transfer points at suburban shopping developments, including Stuyvesant Plaza, Crossgates Mall, Colonie Center, and Latham Farms. The route operates on 30-minute headways from 9:00 a.m. to 10 p.m. Monday through Friday and from 8:20 a.m. to 10:20 p.m. on Saturday.

8.6.3 Other Efforts

To date, the CDTA has targeted service innovation mainly at employment centers. Residential areas receive more traditional services. However, the agency has several other innovations under development to improve the entire system's speed, efficiency, and on-time performance. A new CDTA subsidiary is attempting to coordinate the provision of social service paratransit by the various area providers. If successful, the system will lead to more efficient use of the large, uncoordinated social service fleet. CDTA is also testing of alternative fuels, and is investigating a signal priority system which will keep stoplights green when buses are approaching intersections.

8.7 Evaluating the Shuttles

8.7.1 Customer Reactions

CDTA conducts occasional surveys of its customers. Feedback on the shuttle services has been very positive. The 1997 ShuttleBug customer survey revealed that riders most liked the shuttle's convenient schedule and the fact that it gets them to work on time. Respondents also appreciated ShuttleBug's curb-to-curb service. The 1998 survey, which included the riders of all three shuttles, found a very high customer satisfaction with the system. Over a set of four service attributes, the average customer satisfaction rating was 4.5 on a scale of 1 to 5. A similar survey of riders of CDTA's regular bus routes found a rating of 3.9 for the same attributes.

8.7.2 Access and Circulation

The principal goal of CDTA's shuttle services was to improve access to jobs. The shuttles provide the "missing link" in reaching suburban business parks, especially for those who do not own cars. About 80 percent of ShuttleBug passengers and 70 percent of ShuttleFly passengers believe the service has helped them get or keep their jobs, and a preponderance of riders on these shuttles use the service mostly for work trips.[12] Interestingly, the ShuttleBee serves a somewhat different market than ShuttleBug and ShuttleFly. The ShuttleBee ridership has a much greater proportion of seniors and students and more within-corridor trips.[13] The agency attributes this to the existence of a community college and several retirement homes on the route, as well as several restaurants.

Despite the main goal of improving access to dispersed employment sites, the shuttle services have also impacted air quality and congestion by attracting choice riders. The share of riders who have a car available to them is 22 percent, 48 percent, and 31 percent for the ShuttleBug, ShuttleBee, and ShuttleFly respectively. For the same routes, the shares of passengers who traveled by automobile prior to shuttle service are 7 percent, 22 percent, and 18 percent.[14]

8.7.3 Productivity

Like many agencies using flexibly routed transit, the CDTA downplays most traditional numerical measures of shuttle performance. The agency feels these measures undervalue the importance of the shuttles in providing access to jobs. That is, they reflect service outputs, not outcomes (e.g., securement of a job). At the same time, the shuttles' hostile land use environments make low productivity a nearly foregone conclusion. Nonetheless, what such statistical measures of these services do show is robust growth and increasing popularity.

The most mature of the three shuttle services is the ShuttleBug, having been in service for over two years. The ShuttleBug has steadily gained ridership. ShuttleBug had 13,000 riders in its first year of operation. By the second year, ridership topped 32,300, an increase of almost 150 percent.[15] ShuttleBug's ridership has begun to level off, and is currently in the range of 150 to 170 per day, around 8 riders per hour.[16]

As newer services, the ShuttleBee and ShuttleFly are still developing their ridership markets. ShuttleBee carries around 75 riders per day, and CDTA hopes ShuttleBee will eventually carry as many riders as the ShuttleBug. Weekday ridership has grown very quickly for ShuttleFly, the newest service. The agency's goal for ShuttleFly was 250 riders per day. The shuttle was already regularly exceeding that by mid-1999. ShuttleFly Saturday service is less popular and serves about 90 passengers per day.[17]

CDTA is facing a slow decline in system-wide ridership. As a small addition to the agency's services, the shuttles have not been enough to reverse that trend. Ridership on the strong core routes that connect to the shuttles has not perceptibly changed due to the shuttle services.

8.8 The Future of Albany's Shuttles

The Capital District Transportation Agency has been very happy with the shuttle services thus far and hopes to improve current routes and add new shuttles where possible. A 1998 customer survey showed a strong desire for extended evening service hours on the ShuttleBug and ShuttleFly routes as well as weekend service. Extended hours may be quite appropriate to the shuttle routes' target clientele, since many entry-level jobs have schedules outside traditional work periods. The 1998 survey also included information on user worksites, which the agency hopes to use to target future business outreach efforts. More distant plans include adding shuttle routes in several new areas, and experimental use of shuttle routes in low-ridership but more traditionally urban areas.

For the ShuttleFly service, CDTA plans to add buses to shorten headways to ten minutes during morning and evening peak periods. One possibility that may help bring this about is the creation of partnerships with area hotels. While ShuttleFly service has, despite its name, not been targeted to persons catching flights at the airport (the buses do not even have luggage racks, nor does the service guarantee tight arrival times at the airport), CDTA is considering the possible benefits of some type of partnering with hotels, many of which have airport shuttles of their own This pooling of resources might allow the agency to extend ShuttleFly service hours as well as add vehicles at no additional cost.

In general, CDTA benefits from a supportive metropolitan planning organization, and the agency has been successful at getting flexible monies applied to transit. The ShuttleFly also has another possible funding source in that the town through which it runs, Colonie, has agreed to fund 50 percent of operating costs with its development mitigation fees should the route prove successful. CDTA is seeking additional funding through for TEA-21 for technology upgrades, such as computer-aided dispatch. The agency has also applied for funding under Access to Jobs and state Welfare to Work programs to extend service hours.[18]

8.9 Learning from Albany

CDTA has focused on introducing shuttle services to employment areas which are still growing. Putting the transit service in place prior to an area's build-out gives potential employees who are transit-dependent access to new jobs as they are created. Initiating service *after* businesses have hired their staffs would mean that fewer employees would require transit service when it is finally implemented, as potential riders would have either made other arrangements to get to work or foregone a job in the area because of their inability to get there. Shuttle ridership would thus be wholly dependent on worker turnover at established firms.

The degree of difficulty in operating a flexibly routed shuttle rises with the number of deviation requests. To date, the shuttles have not incurred systemic capacity constraints, although individual situations have arisen where a bus has had too many deviations to serve within the time allotted. Wheelchair lifts on the buses are relatively slow, which affects performance if a disabled person uses the service. Bad weather also slows the system, but the routing flexibility allows the driver to adapt.

CDTA has successfully involved the needs of users (mostly commuters) in the initial design of the shuttle services through the agency's contacts with businesses. Gathering data such as the numbers of potential riders, their probable needs, and even pedestrian amenities has allowed the agency to focus service on customer needs from the very beginning. This is not to say that there have been no surprises. In the case of ShuttleBee, ridership has been more varied than expected, serving many trips within the area as well as commute trips. Nonetheless, involving businesses has helped CDTA adjust shuttle times and fixed route transfer connections to business start times.

CDTA's financial ingenuity has allowed the agency to create shuttle services while maintaining existing traditional services. By using lower-cost labor and securing grant assistance, the agency has been able to experiment with new routes and service strategies.[19]

Overall, CDTA and its riders have been very pleased with the shuttle program. Granted, shuttle ridership is relatively small and productivity low in comparison to more traditional routes. But, where a transit provider attempts to serve dispersed, single use environments which are hostile to transit, it is important to measure success not just with traditional productivity indicators. Albany's shuttles are well suited to the unique mobility needs of the region's suburban workers. For some, the shuttles have provided vital access to job opportunities available nowhere else in the region.

Notes

[1] Federal Transit Administration, *Transit Profiles. Agencies in Urbanized Areas Exceeding 200,000 Population, for the 1995 National Transit Database Report Year* (U S. Department of Transportation, Federal Transit Administration, 1996).

[2] Source: Capital District Transportation Committee, *New Visions for Capital District Transportation Regional Transportation Plan* (Albany: Capital District Transportation Committee, 1997). While 15 percent of workers living in the city of Albany still commuted by transit in 1990, the proportion for the Albany-Schenectady-Troy MSA was only 4 percent. Source 1990 U.S. Census

[3] One reason for this is the region's relatively slow growth. Between 1980 and 1997, the number of employed workers grew from 331,000 to 395,000, or just over 1 percent per year Source: Capital District Regional Planning Commission, *Capital District Average Annual Civilian Labor Force* (9 June 1999 <http://www.cdrpc.org/lf_cdr.gif>). In addition, much of the region's sprawl development has been made more accessible by its "inward" location, within the triangle formed by the three major central cities Albany, Schenectady, and Troy.

[4] CMAQ (Congestion Mitigation and Air Quality Improvement Program) was created in 1991 as part of the Intermodal Surface Transportation Efficiency Act (ISTEA). The program funds projects intended to aid attainment and maintenance of national ambient air quality standards (NAAQS) set under the Clean Air Act (CAA).

[5] C. Cohen, *Review of CDTA Shuttle Services* (Memo and report to CDTA executive and deputy directors, 28 December 1998)

[6] Regular fares for the CDTA system are zonal, varying from $1 00 to $1 55.

[7] C. Basile, *Customer Survey Report CDTA Shuttle Services* (Memo and report to CDTA senior staff, 11 December 1998).

[8] C. Cohen, 1998.

[9] C Cohen, 1998.

[10] CDTA's monthly passes are known as Swiper cards and are used by about 25 percent of CDTA riders.

[11] The best example of this is the reconstruction of part of the ShuttleFly corridor scheduled for 2001. Working with the area's MPO and the New York State Department of Transportation, CDTA has arranged for Wolf Road to get sidewalks, bus turnouts, and access management (driveway consolidation and parking lot connectivity).

[12] According to the December 1998 Customer Survey Report, 97 percent of ShuttleBug riders use the service for work trips, as do 90 percent of ShuttleFly riders

[13] Only 43 percent of ShuttleBee customers use believe the service has helped them get or keep their jobs, and 61 percent of riders use ShuttleBee mostly for work trips (compared to a system average 70-75 percent) The less employment-specific character of ShuttleBee's ridership becomes apparent in that 17 percent of ShuttleBee riders use the service for shopping trips, and 22 percent use the service to get to school. Source: C. Basile, *Customer Survey Report: CDTA Shuttle Services*, 1998

[14] C. Basile, *Customer Survey Report: CDTA Shuttle Services*, 1998.

[15] Also, average riders per day went from 54 in the first year of service to 127 in the second, a 134 percent increase Sources: C Basile, *ShuttleBug Ridership Summary* (Report to executive director, 27 January 1998), and C. Basile, *ShuttleBug Ridership Summary* (Report to executive director, 10 July 1998)

[16] ShuttleBug registered its highest ridership, 9 3 riders per hour, in September 1998. Source. C Cohen, 1998

[17] ShuttleBee currently averages around 3.5 riders per hour, and ShuttleFly averages around 6 riders per hour. Sources: C Cohen, 1998, and K. Younger, email to the author, 8 June 1999.

[18] CDTA is concerned, however, that the service remain attractive to a wide range of users. While the purpose of the system is job access, the agency prefers not to target shuttles *only* to "welfare to work" users, or to allow the services to be perceived as such CDTA has been awarded the federal Access to Jobs grant, which the agency will use to extend service hours and make several strategic shuttle route extensions.

[19] This has allowed the agency to test the shuttles' effectiveness as well as build rider support The long-term stability of such a strategy is somewhat unclear. The agency has used local CMAQ funds to fund the shuttle routes so far, as well as a combination of other normal funding sources. After CMAQ monies are exhausted, CDTA will need to find a permanent source of revenue. Also, it may be difficult in the long term for the agency to retain the lower driver-pay scale for shuttle drivers than for drivers of larger buses. It seems possible that the union will insist on wage parity, especially if the shuttle system is expanded to new areas

Chapter Nine

Flexibly Routed Neighborhood Shuttles: Winnipeg, Manitoba

9.1 Synopsis

Faced with declining transit ridership and a dispersing population, Winnipeg, Manitoba, a mid-sized city in the central Canadian plains, has introduced innovative and flexible neighborhood shuttles for low-density areas. This system replaced portions of several pre-existing fixed routes with small-area dial-a-rides linked to timed transfer centers, creating a more personalized, neighborhood-scale bus service well suited to the circuitous street patterns of single-use, low-density neighborhoods. The transit agency designed the service as a reaction to a specific set of needs, and has explicitly treated the new system as an experiment, monitoring rider preferences and riding patterns and adjusting service as necessary. Designed for circulation and access to and from the larger transit network in low productivity periods, especially where a general outward (home-destined) ridership direction predominates, the service will be used as a ridership development tool in some areas, and as a permanent service in others. In the absence of limits on the dispersion of residential and commercial land uses, this service shows Winnipeg's determination to serve an evolving environment by adapting its service to the changing need of its patrons.

9.2 Taking Transit to the Neighborhoods

Winnipeg, Manitoba, is a city of 625,000 inhabitants situated near the geographic center of the North American continent [1] While Winnipeg has experienced slow population growth, it has at the same time experienced a steady dispersal of population.[2] The region currently has few land-use controls on development, and Winnipeg's flat setting provides ample, easily-developable land At the same time, Winnipeg's downtown remains a center of shopping, entertainment, and housing. The downtown is home to the city and provincial governments, and contains almost 27 percent of the region's employment.[3]

Thus, while downtown Winnipeg provides a reasonably dense and more traditional destination for fixed-route transit service, continuing dispersed development outside the central business district is ill-suited for point-to-point service. Winnipeg Transit experienced a steady decline in ridership, from 60 million revenue passengers in 1982 to 40 million in 1995. Since that time, yearly ridership has remained steady at around 40 million. The suburbanizing land use situation is also exacerbated by Winnipeg's continental climate. Winter weather can at times be severe, making the walk to a bus stop and the wait for a vehicle difficult.

Winnipeg Transit has sought new ways to serve a suburbanizing service area. Most notably, in 1996 Winnipeg Transit introduced innovative Dial-a-Ride Transit (DART) services. Replacing portions of fixed-route service, these general-public dial-a-ride zones link the widely-distributed locations within the zones and provide access to remaining fixed route service and the rest of the city. Passengers are picked up at their homes or other locations, or can board buses at transfer stations, and are delivered to designated stops throughout the DART service areas

9.3 Serving the New Patterns

Despite the difficulty of serving an increasingly dispersed city, some residents in Winnipeg Transit's outlying service area were requesting improved transit service. Fixed route service is successful in most areas during peak hours, but the agency wished to find a way to better serve dispersed areas during periods of low demand. In addition, the agency sought a way to serve new areas before they had become developed enough to support regular service, hoping to get people used to riding transit.[4] Transit planners felt that these people would be much more difficult to win over to transit after they had been forced to buy a car because of the unavailability of transit services.[5]

The agency's solution was a new neighborhood-scaled dial-a-ride system, integrated into the larger transit network. The stated purposes of the new service were to pick up and deliver passengers closer to their homes, provide more direct travel where possible, and eliminate operation of large vehicles through residential areas during low demand periods.[6]

From the beginning, Winnipeg Transit explicitly treated the project as an experiment, which allowed more freedom and creativity in the service design. The design process included reviewing demand-responsive services in other cities and an earlier dial-a-bus experiment in Winnipeg in the 1970s. Service simulations allowed the agency to test scheduling, routing, and drop-off and pick-up options, as well as to gauge driver training requirements.

9.3.1 Implementation

In June 1996 Winnipeg Transit began the trial demonstration of DART service in two suburban residential areas of Winnipeg on evenings and Sunday mornings, periods of low demand (Photo 9.1). The goals of the initial service were to refine service delivery, test winter driving conditions, determine travel behaviors, assess cost effectiveness, and discover whether passengers would like such a service.[7]

In April 1997 the agency expanded the operating hours of the initial routes to include Saturday mornings and all-day Sundays. At the same time service was instituted in two other areas, one on weekday and Saturday evenings, and the other on weekday middays and Saturdays. The new evening route was soon converted to late evenings only, as it became apparent the route was much too busy in the early evening, and the driver was unable to serve all passenger requests. From an original start time of 7:00 p.m., the agency converted the area back to fixed-route service prior to 10.30 p.m. a week and a half later. In September 1997 the agency created a final DART route, with service on weekday middays and Saturdays.[8]

Based on customer comments, in 1998 the agency returned service during daytime periods (except Sundays) to fixed route. Customer input about evening service has been very positive, and

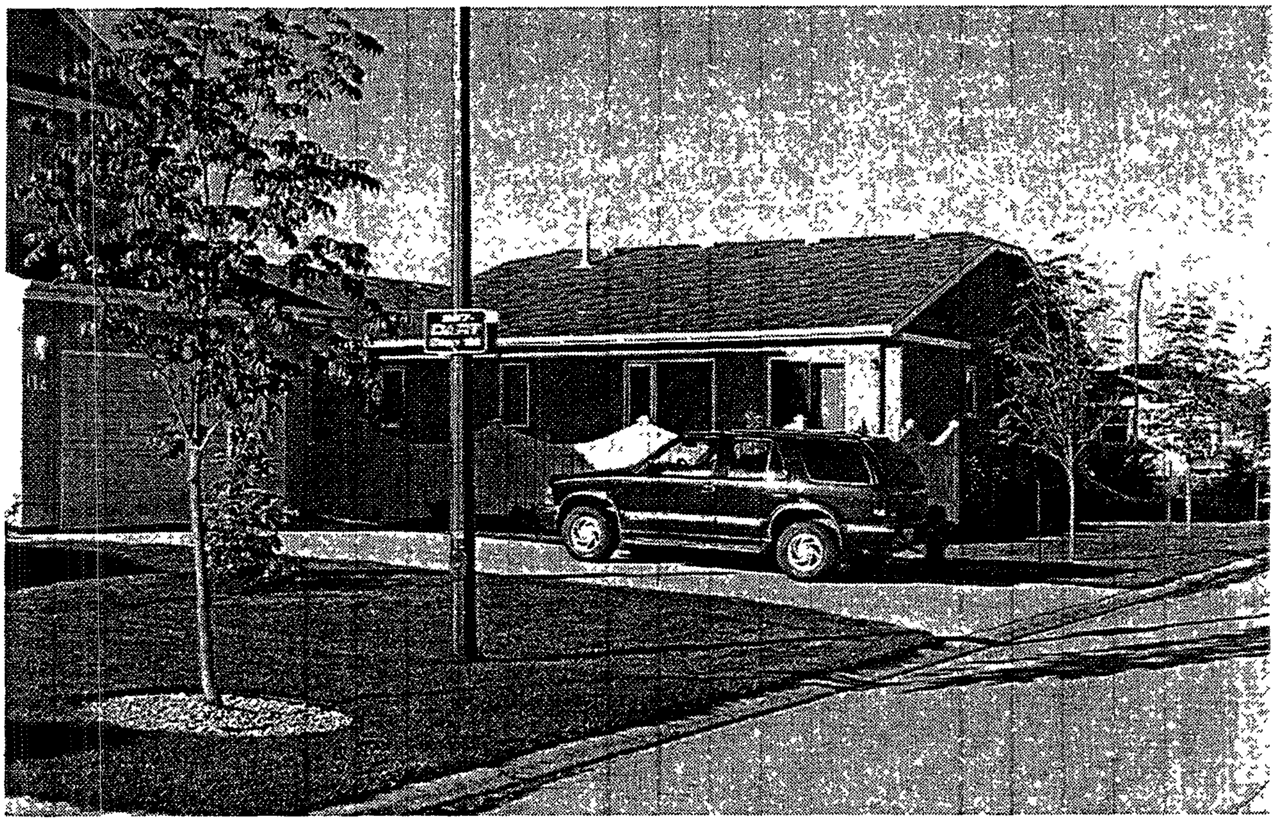


Photo 9.1. A typical street in the DART 102 service area. As in the photo, sidewalks are often absent. DART stops in this area are simply signs mounted on light poles, as above. Signs show the DART logo, stop number, and reservation phone number.

the agency plans to maintain DART service during those periods and expand to new areas in the year 2000.[9]

9.3.2 Marketing

At the institution of the service, Winnipeg Transit did a mailing of DART timetables and brochures to all addresses within the service areas. In some cases, the DART service-area maps are combined in one brochure with the timetables and maps of fixed routes which serve similar areas during non-DART periods. To aid DART users, the agency has created displays at the transfer centers with route and schedule information.

9.4 DART Services

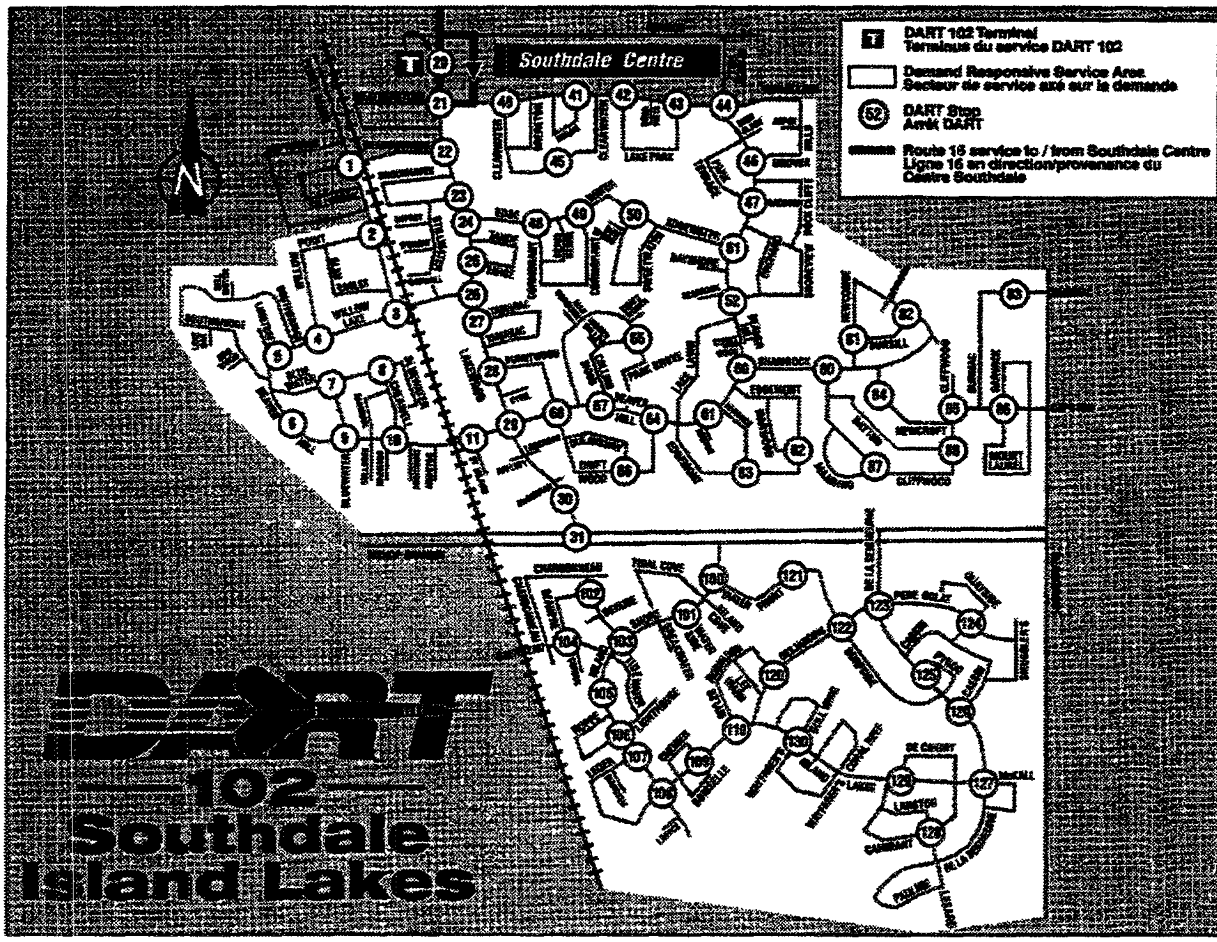
DART service areas are suburban, with low-density single-family housing as the predominant land use (Photo 9.1). Street patterns are often circuitous, and include some narrow streets and cul-de-sacs. The areas generally retain fixed route service on preexisting alignments during non-DART periods.

During service hours, the DART routes coordinate transfers with fixed routes. Transfer stations are located at major trip generators, often shopping centers (Photo 9.2). Passengers may board either at the transfer stations or may call in to request a pickup at another location within the service area. Passengers boarding at transfer stations do not have to call ahead to request a drop-off. Instead, they tell the driver their destination when they board. Regular fares are charged for DART service, despite its "premium" characteristics.

Photo 9.2. The DART Route 102 transfer center. This transfer point is located at Southdale Centre, an auto-oriented shopping plaza. The Route 16 fixed-route bus is in front, and the Route 102 DART bus is in the rear. The sign on the sidewalk contains a DART route map, including labeled stop numbers, and an explanation of the service. This shopping center is also the location of one of Winnipeg Transit's park-and-ride lots.

DART buses also make pick-ups in response to call-in requests (usually at a passenger's house). Call-in requests for DART passenger pick-ups are forwarded by an automated system to the correct DART operator's cellular phone, eliminating the need for a separate dispatch function and allowing callers to access any DART route through a single phone number.

For drop-offs within the service area (other than transfer centers), the bus driver determines the best path for the route based on passengers' requested stops. The DART service areas have designated, numbered stops located at close intervals throughout the area for drop-offs (Map 9.1). A passenger may be delivered to any DART stop in an area or to a transfer station.



Source. Winnipeg Transit, effective 13 April 1997.

Map 9.1. Dart 102: Southdale-Island Lakes Service Area. Drivers use one sheet for each circulation through the service area, marking stop requests on the map and plotting a route.

9.4.1 Service Features

DART buses pick up passengers at their homes or other requested locations. Because the pickup time is not scheduled precisely, this relieves passengers of the need to wait outside, and is partially an adaptation to the severe Winnipeg winter weather. The agency discourages drivers from honking at pick-ups so not to disturb neighbors. Normally, passengers are watching for the bus and there are few missed pickups. Buses drop passengers off at stops, because no wait is involved, and stops are distributed widely throughout the service areas. Dropping passengers at designated stops may allow a driver to consolidate drop-offs, saving time, and may also allow a driver to use a more efficient route with fewer turn-arounds. Still, the agency allows drivers to decide the precise level of service based on their judgment. For example, to allow flexibility in routing, a driver may drop a passenger at any corner of an intersection flanked by a DART stop. Conversely, a driver may drop a passenger directly at his or her home if the driver feels there is enough time.

To allow drivers to more accurately estimate pick-up times, the agency informally splits DART routes into sub-areas. Because of the use of timed transfer centers, a bus usually circulates through its zone in a general pattern of outbound and inbound (although some routes circulate between several transfer centers). Using this pattern, the agency assumes that the bus will be at the furthest point from the transfer center at some specific time between synchronized connections. The bus drops off passengers going from the transfer center on the outbound portion of the route and picks up people going to the center on the inbound portion. Thus, an outbound bus might pass the house of a passenger who is going to the transfer center, planning to stop on the way back.

This system works to keep passengers on the bus for the shortest time, although some passengers are confused and believe the bus driver has forgotten to stop for them. About 75 percent of passengers on the DART system are outbound (usually home bound) from transfer centers. This pattern is a result of the periods in which DART services are available and is by design. Drivers fit the trips of passengers making trips with both origin and destination within the same DART service area into this general framework, delivering them as directly as possible. The sub-area system is not restrictive, so a driver may go back to a "previous" zone to give a passenger a more direct trip if time is available. Given the ability to set routing, drivers often refine this system based on their knowledge of the area. One driver has used his knowledge of the area to develop his own time schedule for even more accurate estimations of pick-up times. It is this type of ownership of the route and ability to be creative that attracts some drivers to the service.[10]

9.4.2 Training

Winnipeg Transit's training section has developed a special training package for DART drivers. This training is in addition to the regular bus driver training. DART training lasts one day, sometimes consisting of a full day of classroom training, and sometimes of a half day of classroom training and a half day of riding with an experienced DART driver. Instruction includes trial runs of planning trips and deciding the optimal routing through the area. The agency has also developed an extra service review for DART to help drivers refine their performance.

The tools for use by DART drivers have evolved over time. Currently drivers have a route map (Map 9.1) and schedule on one sheet, and a cross-reference sheet for route connections.

9.5 Hurdles Overcome

9.5.1 Equipment

One of the goals of DART service was to reduce the use of large buses in residential areas. This led Winnipeg Transit to choose "Elf" buses, which looked less like regular buses due to their van fronts. It was hoped that residents would see these buses as less of an intrusion into the neighborhoods. However, the agency found the Elf buses to be undependable, to perform poorly in snow, to ride roughly, and to have too large a turn radius for the narrow streets of the service areas.

The agency has since replaced the buses with 30' low-floor buses with short turn radii. These new buses look much more like regular full sized buses, and have no special features for

DART service other than plug-ins for spotlights (drivers use spotlights to find house numbers at night). Still, there have been few complaints, and public response has generally been quite positive in all DART service areas.

9.5.2 Weather

A minor problem has been weather, in that the buses often go into small neighborhood streets that do not receive the same priority for snow clearance as do major streets. The agency has found that operating speeds are lower in winter. However, even with higher winter ridership, DART service has very rarely arrived at the transfer station late. During particularly severe conditions, the flexibility of the system comes favorably into play. A bus may only be able to serve certain portions of the area, such as the former fixed-route alignment. In that case, the driver drops off or picks up the passenger as close to the requested site as he or she finds passable.

9.6 Winnipeg's Other Transit Adaptations

In its overall effort to provide transit service which can better compete with automobiles and better serves the Winnipeg area, Winnipeg Transit has implemented several other measures to benefit riders and speed service. Taken together, these show a more comprehensive effort to improve the prospects of transit performance and ridership.

9.6.1 Transit Priority Measures

The agency has implemented several transit priority measures to aid the speed and on-time performance of fixed-route services. Among these are peak period bus-only diamond lanes and contra-flow bus-only diamond lanes. In addition, transit priority signals at some high-traffic intersections give buses a 6-second head start on other traffic and thus allow them to merge into traffic (Photo 9.3). The agency has calculated that in some instances the signals save buses two to three minutes during congested periods, while delaying traffic only a matter of seconds.[11]

In 1994, Winnipeg created a bus-only and bus-priority street in the downtown known as the Graham Avenue Transit Mall. This project closed five blocks of Graham Avenue to automobile traffic, widened sidewalks, and added bus shelters and distinctive street furniture. Outside the bus-only portion, to the point where the street ends in a "T" intersection at the large Hudson Bay department store, the project narrowed the street to two driving lanes and two parking lanes. The project has created a downtown transit-focused district and a transit identity, which the agency has attempted to accentuate through such actions as naming stops, as would be done in a rail transit system

9.6.2 Telebus system

The Telebus system allows transit users to call in to find out the scheduled bus arrivals for a particular stop. Unlike some similar systems, callers do not receive real-time information about

Photo 9.3. A transit priority signal in operation. The vertical white light signals the bus to proceed, while the light stays red for automobiles.

bus arrivals. Instead, they are informed how soon a bus is scheduled to arrive at a particular stop. Still, the system is extremely popular, receiving over 10 million calls in 1997.

9.6.3 Park-and-ride lots

Winnipeg transit has entered into agreements with several shopping centers to make park-and-ride spaces available in the shopping center parking lots. Shopping center managers often agree to host a park-and-ride under the idea that allowing this use of their parking lots during periods of slow demand makes it more likely that their centers will gain the business of the lot patrons on their return to their cars.

9.7 Evaluating DART

DART service's are well tailored to the mobility needs of suburbanites. The service shortens walking distances, offers personal safety, and in some cases provides curb-to-curb service. Considering the combination of access to the bus (usually walking to a stop) and the trip, DART provides users with an easier trip than fixed-route service overall. The DART system provides a service that is of a neighborhood scale and feel.[12] Direct, seamless transfers to regular fixed-route service allow users easy access to the wider city and region. The service spreads impacts more broadly, in that buses only travel down streets as necessary, and the buses are smaller than regular buses. Neighborhood feedback about DART service continues to be very positive.

Productivity for DART routes is low compared to other routes, as can be expected for a service targeted at low-density areas during off-peak periods. For example, in 1998, DART routes

101, 102, and 109 averaged 7.1, 12.5, and 14.8 boardings per hour respectively on weekday evenings, compared to a weekdays system total of 50.3 boardings per hour.[13] It is important to keep in mind, though, that system totals include peak hour trips, whereas DART routes operate only in periods of low demand. Unfortunately, it is difficult to contrast the performance of DART service with previous service to the same areas. There are few historical numbers to compare. For normal fixed routes, Winnipeg Transit computes passengers and boardings statistically using farebox revenues and knowledge of the types of boardings and the revenues each type generates. In the absence of specific counts, there is no way to gauge the number of passengers using bus service in the DART areas prior to service. And, because the trunk routes to which the DART routes connect are so much larger than the DART routes, variations in their ridership due to DART service would be statistically insignificant.[14]

DART service has not performed well in all situations. As noted, Winnipeg Transit eliminated DART services during daytime periods. It was during these periods that many trips originated at homes, and thus required reservations. The agency found DART more popular and well accepted during periods in which most travel is "outbound"; that is, travel consists of trips returning to destinations within the service area. At other periods (middays on weekdays and Saturdays), passengers indicated to the agency that they did not like the requirement of dialing in for a trip. For riders transferring from fixed-route service, the change to DART is more transparent. This mix of results was not unexpected, considering the agency's treatment of the service as an experiment. One interesting finding of evaluations is that DART is at times a significant provider of intra-area (residence to residence) mobility, rather than just access to transfer points.[15]

The cost impacts of a service like DART vary by route and service design. The financial impact on such measures as bus hours will depend on the way in which the service interacts with the remaining fixed-route service, either allowing fewer total hours or creating the need for more bus hours. In full operation (day service included), DART service reduced overall daily bus hours by 3.8 hours on weekdays, 13.5 hours on Saturdays, and 1 hour on Sundays. This was partially due to the fact that DART service ends at a somewhat earlier time than the former fixed-route service. Other DART service costs may also vary from fixed-route service. For instance, the use of smaller buses may reduce costs, while cellular phone usage will increase costs.

Considering the goals of providing a neighborhood-scale service that would provide residents easier access to their homes and ease tripmaking, Winnipeg Transit considers DART service a success. Because a single vehicle serves an area, the driver can better stay on top of a route and give management feedback on how it is functioning. The service has garnered much community support and very few complaints. Ninety-two percent of respondents to a November 1996 survey rated the service Good or Excellent.[16] This type of support, especially considering the political realities of the influence of more affluent suburban areas, could be beneficial for the agency's position in general.

9.8 The Future of Winnipeg's DART

Winnipeg Transit has found that DART's flexible service can be better suited to the needs of the growing portion of its customers in the suburbs. In addition to the new DART routes to be implemented in the year 2000, the agency also has tentative plans to use a DART-type service as a ridership development technique in a newly developing area. When the area is more fully developed and ridership justifies it, the agency could implement fixed route service. In the meantime, DART will get residents accustomed to using transit, and keep people from having to acquire automobiles in the absence of transit service.

Winnipeg Transit has explicitly treated DART service as an experiment. This entrepreneurial attitude has allowed the agency leeway to change the service as necessary and as travel behavior became more apparent. It has also given Winnipeg Transit's passengers a better idea of what is happening with their transit service and has hopefully given them a greater appreciation for the service and understanding of its possible benefits. In an area with dispersing land uses and changing travel patterns, a quality, user-friendly transit service will be even more difficult to provide in the future than today. Winnipeg Transit is looking to flexible, neighborhood-scaled DART dial-a-ride service and other adaptive strategies for long-term ridership and customer service benefits. The agency's willingness to investigate new service concepts, and learn from successes and mistakes, should be the key to its future success.

9.9 Learning from Winnipeg

From the experiences of Winnipeg Transit, it is apparent that dial-a-ride transit cannot be a highly productive service compared to successful fixed-route service. If the route serves too many passengers, service quality begins to falter. As a general rule, DART service works only up to a level of about 20 passengers per trip (circuit). Since a circuit is usually one hour, that means the system can serve a peak of only about 20 passengers per hour. Adding another bus to improve service would, of course, drive down efficiency again. The DART system will, by design, be low-productivity, which is also not surprising considering the type of area DART was designed to serve.

The input and support of labor is an important ingredient of success. Winnipeg Transit involved the drivers' union from the start, even in the design phase. The agency also involves the operators in ongoing improvements to the service. Involving labor has created a better system by incorporating the knowledge of drivers, as well as helping to reduce resistance to the introduction of new services. Paying DART drivers the same as other drivers promises to avoid much of the conflict that some agencies incite through differential pay scales. While this has made DART's cost per trip even higher, the costs for DART riders are not *new* costs to the agency. Rather, DART costs are former fixed-route costs shifted to the new service, serving the same customers better.

Despite the neighborhood scale of DART services, Winnipeg Transit has found neighborhood resistance to placing bus stops in some areas. Buses may not fit some people's idea of what their neighborhood is, despite the requests for suburban service which generated the initial search for new service alternatives. Most homeowners have grown comfortable with having buses on their streets, however.

Dial-a-ride services are flexible and can be tailored to the needs of specific areas. For instance, DART routes vary in their configuration of transfer points and fixed time points. Some routes have only one fixed, timed point, but others have several or even portions of the route which are equivalent to regular fixed-route service. A DART route can be easily adapted to an area's unique land uses, road patterns, and other available transit connections. Winnipeg Transit drivers have further flexibility to serve their customers as they see fit, if they are still able to achieve their core service requirements.[17] The agency encourages operators to tailor service to the passengers, serving the needs of individual customers as well as possible.

Like many instances of flexible routing we studied, DART service has been flexible and effective in targeting a specific transit-user market. In this case, the market is home-bound trips to suburban areas during low demand periods. Targeting service in this way means that in few instances could such a system be copied completely for another area. But, in a suburbanizing region, service types suited to more dense and urban land use patterns find their ridership shrinking. Market segmentation allows transit service to be specifically tailored to its market. In an era of diversifying consumer needs, it makes perfect sense.

Notes

[1] City of Winnipeg, *Statistics and Information* (15 June 1999 <http://www.city.winnipeg.mb.ca/html/stats/stats.htm>)

[2] Between 1991 and 1996, Winnipeg's population grew by 0.3 percent. In the same period, the area immediately surrounding the city grew by about 10 percent. Source City of Winnipeg & Province of Manitoba, *Winnipeg Transplan 2010: Moving Toward Solutions* (Winnipeg City of Winnipeg & Province of Manitoba, 1998).

[3] City of Winnipeg & Province of Manitoba, 1998.

[4] Unlike some agencies using flexibly routed transit, Winnipeg Transit did not intend for this service to replace paratransit services for disabled persons While there is no identical requirement to the Americans with Disabilities Act (ADA) in Canada, Canadian transit agencies must provide reasonably equivalent service for disabled persons. In Winnipeg this service is called Handitransit. To use Handitransit, a person must have health-care proof certifying need, must register, and must book rides two days in advance. For various reasons, DART service does not take the place of Handitransit. For one, Handitransit offers door-to-door service (versus curb-to-curb), which DART does not. Additionally, while Winnipeg Transit is currently in the process of making the regular bus fleet more accessible by going to all-low-floor buses and retrofitting bus stops, a disabled passenger could currently not go outside the DART service area because most buses are not accessible Finally, DART is an evening and weekend service, where Handitransit trips are largely during the day.

[5] A valid concern Studies have indicated that the presence of more cars in a household leads to a lower likelihood of transit use For example, see R. Cervero and K. Wu, *Influences of Land-Use Environments on Commuting Choices: An Analysis of Large U.S. Metropolitan Areas Using the 1985 American Housing Survey* (IURD Working Paper 683, UC Berkeley, 1997).

[6] Winnipeg Transit Department, *RE. Demand Responsive Transit (DART) – A Trial Demonstration* (Report to Committee on Works and Operations, 29 March 1996).

[7] Winnipeg Transit Department, *RE: Evaluation of DART (Dial-A-Ride Transit)* (Report to Committee on Works and Operations, 30 January 1997).

[8] DART service areas are relatively small residential districts. They range from about 6,000 to 12,000 residents, and from about 2,000 to 4,000 housing units.

[9] Winnipeg will host the Pan Am Games in 1999. Winnipeg Transit is heavily involved in planning to serve the games, and will have little time to plan new DART routes until after the Games' conclusion

[10] For drivers, this system can be a little like running their own transit system DART service puts a lot of responsibility on the drivers. In essence, drivers do scheduling, marketing, and routing for their zones. When the DART system first began, many operators were leery of the service and reluctant to sign on to it However, many drivers like driving DART routes, and as the program has progressed more drivers are re-signing and drivers with more seniority are signing up.

Drivers for the DART system come from the ranks of the regular fixed-route system, and there is no pay differential for DART drivers. Winnipeg Transit drivers sign up each three months for their chosen route, and drivers get preference by seniority. Thus, a DART route may change drivers every three months This can be problematic because a route is much easier to operate and can be more efficiently run when the driver is very familiar with the DART service area. Also, each route has a regular operator, a swing operator who does the route when the regular operator is off, and possibly holiday operators and other drivers who will do the route occasionally. Thus, it is possible for a single DART route to have as many as six or eight operators during the same three-month period, or as few as two. Due to the system of signing for routes, some drivers may get "stuck" doing a DART route just for a holiday. In this case the driver will not know the area at all and so will usually have a much harder time serving the area effectively

[11] The total scope of Winnipeg Transit's transit priority measures is as follows:

Transit Mall (24 hours)	0.9 km (bi-directional)
Bus-only lane (24 hours)	1.8 km
Bus-only lane (peak hours)	4.4 km
Contra-flow bus lane (24 hours) .	0.6 km
Transit priority traffic signals	8
Exclusive transit terminals	5 at shopping centers, 2 at universities
Transit-oriented streetscapes	2.9 km (all downtown; bi-directional; includes Transit Mall)

[12] For instance, many trips at certain times are by children and begin and end in the DART area, as parents use DART to give their children neighborhood mobility. In general, drivers that like DART service are people-persons. They enjoy public interaction and feel rewarded by the ability to provide DART's customized, neighborhood-type service. In some ways, the agency has found that the service operates similarly to a local grocery store or gathering place. The riders get to know the drivers and each other, and DART service seems to generate respect between operators and passengers and a sense of the service as a part of the community. For example, some drivers will allow small groups of young teenagers to ride a circuit or two in the bus just for fun, giving them somewhere to hang out. The agency feels that the driver is ideally someone who lives in the area served, who will have a greater stake in the area and who knows the area and the people.

[13] DART ridership for 1998 was as follows:

	Weekday Evening	Saturday Morning	Saturday Evening	Sunday All Day
DART 101				
Boardings/day	35	40	33	116
Bus hours/day	4.9	6.7	4.9	17.1
Boardings/bus hour	*7.1*	*6.0*	*6.7*	*6.8*
DART 102				
Boardings/day	65	30	38	80
Bus hours/day	5.2	6.5	5.2	16 5
Boardings/bus hour	*12.5*	*4.6*	*7 3*	*4 8*
DART 109				
Boardings/day	43	-	38	-
Bus hours/day	2.9	-	2.9	-
Boardings/bus hour	*14.8*	-	*13.1*	-

System averages for 1998 were 50.3 boardings per bus hour on weekdays, 32.9 boardings per bus hour on Saturdays, and 29.7 boardings per bus hour on Sundays The system averages are from Winnipeg Transit internal statistical reports. DART averages are calculated from the trip sheets used by DART drivers. Source: B Menzies, email to the author, 16 June 1999.

[14] Route 16, for instance, which connects to two DART areas, averages 14,722 weekday boardings, while the combined average of the DART routes is only 100 weekday boardings. Source: Winnipeg Transit Department internal statistical summary, generated 26 May 1998, and DART trip sheets

[15] An Department evaluation of Route 102 in January 1997 showed that 12 percent of users were making residence to residence trips on weekdays, and on Saturday evenings this proportion rose to 20 percent. In the same evaluation, however, Route 101 evening service had only 4 percent residence to residence trips

[16] Winnipeg Transit Department, *RE. Evaluation of DART (Dial-A-Ride Transit)*, 1997

[17] For instance, an operator's prime obligation is to serve the DART service area. However, a driver may also make trips to nearby areas if possible, at his or her own discretion. DART routes near each other (e.g Routes 101 and 102) may even call each other if a passenger is going from one zone to the other. If the drivers have time, they may meet in the middle and exchange the passenger instead of forcing the passenger to transfer to fixed route to get from one zone to the other This flexibility and freedom motivates many drivers to find new ways to serve their customers, in a way moving part of the service design from the office to the street.

Chapter Ten

Route Deviation and Zoned Dial-a-Ride: Kansas City, Missouri

10.1 Synopsis

In an environment of declining transit use, funding constraints, and political complexity, Kansas City, Missouri, is serving two low-density areas with flexible bus routes known as MetroFlex. In these areas of retail and moderate-income residential development, the routes serve rush-hour commuters with curb-to-curb connections between their homes and fixed route buses to job centers. During midday, MetroFlex provides valuable intra-area mobility. MetroFlex routes have proven increasingly popular, gaining ridership while the Kansas City area has seen a continuing decline.

10.2 Transit in a Difficult Context

The Kansas City Area Transportation Authority (KCATA) is a bi-state agency serving portions of Missouri and Kansas in the Kansas City, Missouri, metropolitan area. The agency serves an area of 173 square miles and a population of over a half million.[1] KCATA is by far the area's largest transit provider, but individual jurisdictions within the area may opt to provide their own transit services.

The Kansas City region has little traffic congestion, high automobile use, and an abundance of freeway miles. Suburban-style low-density development has predominated, matched by declines in central city urban populations. Regional population is increasing, with an expected rise of 23 percent between 1990 and 2020, mostly occurring in suburban areas. Employment is forecasted to rise by about 26 percent over the same period, also mostly in suburban areas.[2] The area has an extensive highway network, with more per capita freeway lane miles than any other large U.S. metropolitan area, and three times the per capita mileage of Los Angeles.[3]

Facing a funding crisis, in 1992 the Kansas City Area Transportation Authority was forced to cut service and raise fares. Minor cuts continued in the mid 1990s.[4] The obvious choices for cuts were low productivity routes in low-density areas, allowing the agency to maintain service in more transit-supportive locations like the urban core. However, political pressures made service cuts in some suburban areas impossible.

Two low productivity routes targeted for elimination were located in the southern portion of the agency's service area.[5] Bowing to political realities, KCATA planners searched for a better way to provide that service. In 1993 and 1994 the agency instituted MetroFlex service in both areas, replacing the existing fixed routes. In the morning and evening, the new services deviate routes. During the midday, the routes provide intra-area mobility with curb-to-curb zoned dial-a-ride service.

10.3 A New Configuration

The fixed-route buses that MetroFlex replaced suffered low ridership.[6] Realizing that the areas' low densities, divided land uses, and lack of pedestrian amenities were major obstacles to traditional service, KCATA sought a new strategy which would make the services more cost-effective and increase their usage.

The agency's solution was a combination of services, each targeted toward the particular needs of users at different times. MetroFlex routes change operations between rush hours and midday periods, informally called "route time" and "flex time." Route-time service is a route deviation system, designed to get commuters to and from activity centers and connections to the larger system. Flex time service is a zoned dial-a-ride, useful for intra-area trips (Map 10.1).

Previous fixed-route service ran along alignments similar to the MetroFlex routes and had similar service hours. Since institution of MetroFlex service,[7] KCATA has changed the alignments only in minor ways.[8] The routes operate Monday through Friday, with no weekend service, and use twelve-passenger vans. Fares are the same as those on other routes, and transfers are free. MetroFlex routes do not take the place of ADA services.

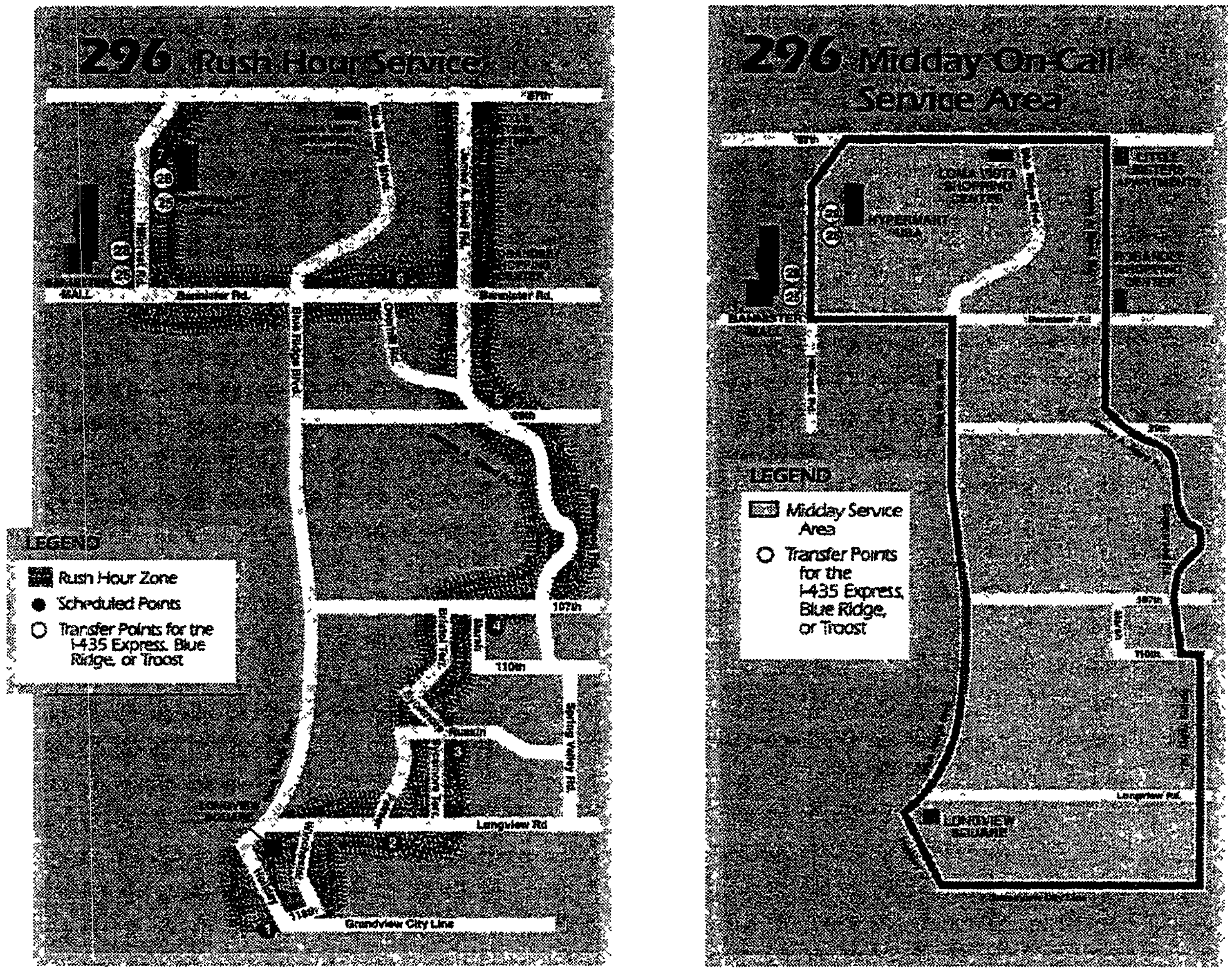
10.4 MetroFlex Services

10.4.1 Rush Hour Service

During rush hour service, MetroFlex buses travel set routes, deviating on request as well as serving several timed points (Photo 10.1). When deviating during route time, buses pick up and deliver customers as close to their origins and destinations as possible, either at the actual location or at the nearest corner. The buses do not go outside the service areas (approximately two to three blocks from the routes) or up dead-end streets. Dispatchers direct riders with trips originating outside the service areas to intersections within the zones for pickup. If a bus has too many deviation requests to serve in a timely manner, the dispatcher may ask subsequent riders to meet the bus at a nearby convenient corner. Besides residential areas, MetroFlex buses also go into retail complexes, delivering passengers directly to storefronts if possible. Riders may also board buses at the timed points along the route, though few do so, or may flag buses down.

MetroFlex routes maintain timed transfers with other routes during rush hour service, including "guaranteed connections" between MetroFlex Route 296 and an express bus to downtown Kansas City. Other timed transfers are not formally set or published, but the system is set up to allow riders to transfer easily.

Rush-hour service is oriented directionally for commuters for Route 296 (but not for Route 298). That is, during morning, Route 296 serves timed stops only while traveling toward the transfer point with the downtown express bus (Photo 10.2 and Map 10.1), and only while traveling away from the transfer point in the evening. In the absence of a phone-in request for service in the opposite direction, the bus simply returns to the beginning point by the simplest route after proceeding all the way in the primary direction. On Route 298, timed points are set in both directions



Source. KCATA, effective 4 April 1994.

Map 10.1. MetroFlex Route 296 – Rush Hour Service Route-Deviation Route (left map) and Midday On-Call Dial-a-Ride Service Area (right map). The service areas are similar but not identical in the two periods. Each map shows major trip generators, and the primary residential area falls in the southern portion of the maps (with north to the top). The major transfer point is near the Hypermart to the northwest.

even during rush hour service, making the route less oriented to commuters proceeding to or from a specific connection.

10.4.2 Midday Service

During midday service between rush-hour periods, MetroFlex buses operate as zoned dial-a-rides (Map 10.1). Passengers call the dispatcher to arrange door-to-door service anywhere within the Midday Service Area. The service area is similar to the rush-hour service area, but expanded in some instances to serve additional trip generators, such as a hospital that the deviating route does not serve. During flex time there are no routes or timed points.

Photo 10.1. A typical bus stop in the MetroFlex 296 service area. Signs give the phone number for deviation requests, and note that stops are served only during rush hours. MetroFlex service areas are of low densities with few pedestrian amenities.

10.4.3 Deviation Requests

Customers make deviation requests through a dispatcher in the KCATA office. According to agency policy, riders should make deviation reservations a day prior to service. In practice, however, dispatchers and drivers attempt to accommodate requests made the day of service, and riders often make same-day requests, including many requests when passengers board MetroFlex buses. In such cases, drivers make the deviations if there is time in the schedule, or get customers as close to their destinations as possible. Regular riders may set up standing orders for pickups. During route time, a MetroFlex route can handle about 12 to 15 deviations per hour.

10.4.4 Driver Pay and Training

KCATA uses three driver-pay scales, depending on the type of bus or route. The categories are drivers of large buses, small buses, and MetroFlex routes, with MetroFlex drivers on the lowest pay scale. MetroFlex drivers receive the same training as regular drivers, plus up to a week of on-the-job training with another driver.

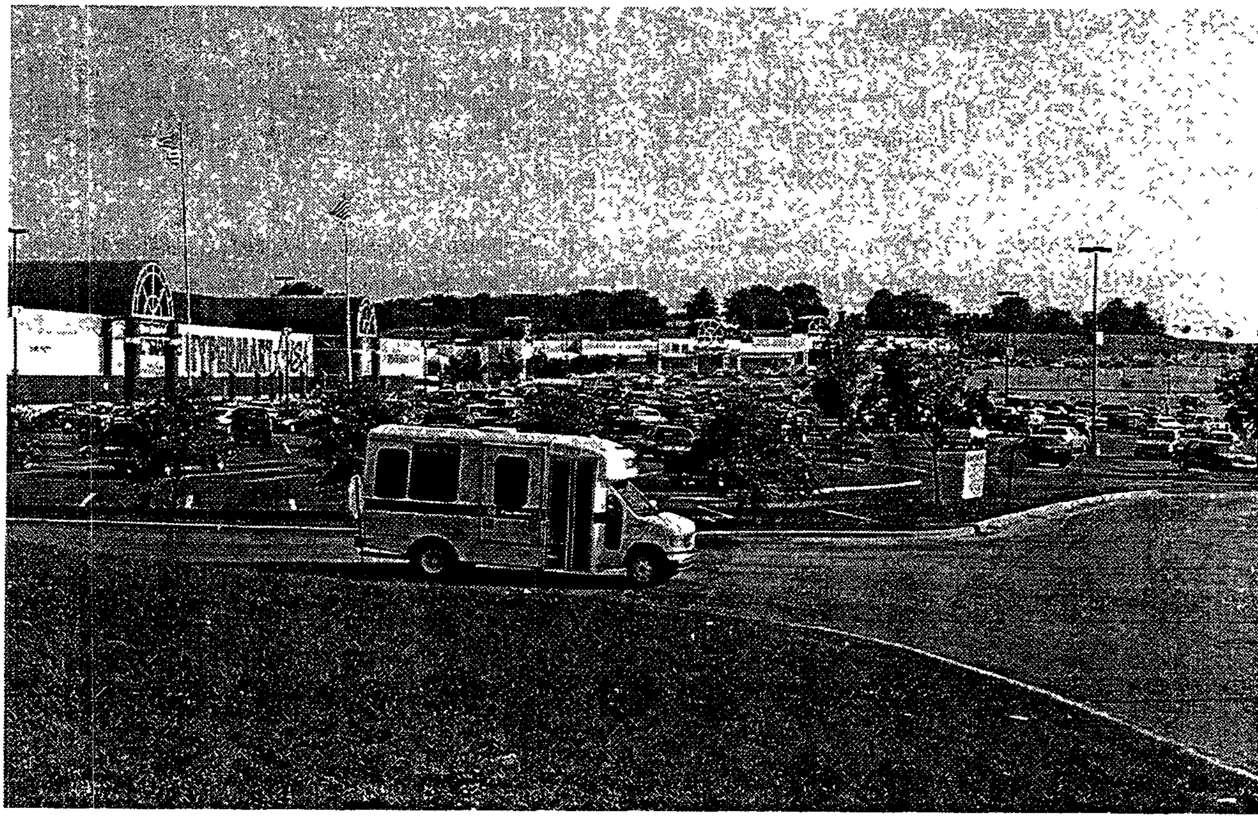


Photo 10.2. MetroFlex Route 296 Leaving the Main Transfer Point. The bus meets several fixed routes near this large shopping complex, which is also across the street from the Bannister Mall, a large regional shopping mall.

10.5 Other Noteworthy Initiatives

In addition to MetroFlex, KCATA has a number of measures designed to improve customer service and system reliability. The agency provides an emergency ride-home program for passengers who purchase a Metro Monthly Bus Pass through their employer. A rider with a pass may receive a free cab ride (related to an emergency) between 8 a.m. and 5 p.m., Monday through Friday. The agency also has a night stop program, where a rider may request to be dropped off at any safe point at night. KCATA uses an automatic vehicle location system to aid dispatchers and to monitor on-time performance. And the agency maintains a system of park-and-ride lots around the area

Finally, KCATA's reverse commute program serves the continuing growth in suburban employment. While most bus routes orient to the Kansas City central business district, the city allocates $300,000 annually to these routes that serve suburban employment centers.

10.6 Evaluating MetroFlex

MetroFlex routes have successfully served their dispersed, suburban markets. By facilitating commuter access to the wider job market during rush hours and giving curb-to-curb midday service, MetroFlex has given its users new mobility options.

MetroFlex has built popularity in an area with declining transit ridership, gaining ridership in nearly every year since its inception. This is especially true for Route 296, which serves the Bannister Mall area. Between 1993, when MetroFlex service began, and 1997, Route 296 has averaged 20 percent gains in average daily ridership each year. By 1997, average daily ridership had achieved 236 percent of the route's 1992 fixed-route performance. Route 298, since being changed to a MetroFlex route in 1994, averaged 16 percent yearly growth in average daily ridership for three years from 1994 to 1996, but had a 24 percent drop in average daily ridership in 1997,[9] still leaving the 1997 ridership at 116 percent of the 1993 fixed-route performance.

By comparison, the KCATA system averaged a 2 percent yearly loss in average daily ridership between 1992 and 1997, although some of this may be attributed to service cuts. As a more direct comparison, two routes in areas similar to MetroFlex areas also fared worse than the MetroFlex routes between the years 1992 and 1997. One lost an average of 3 percent per year in average daily ridership, and the other gained an average of 1 percent.[10]

10.6.1 Ridership Patterns

The two MetroFlex routes exhibit some variation in time of use. In August through December of 1994, Route 296 served 47 percent of its total riders during the midday. Route 298 saw a relatively even distribution of ridership between the a.m. peak, midday, and p.m. peak periods. While the routes had similar ridership totals in the mornings and evenings, Route 296's advantage in total ridership came from its much greater usage in the midday.

The methods of access for Route 296 provide further insight into its ridership market (Table 10.1). During the last five months of 1994, over 50 percent of Route 296 morning riders accessed the service by subscription, appearing to be regular commute trips. During midday, half of the passengers arranged their trips on the day of the ride, indicating more irregular trip types such as errands, shopping, and medical trips. In the p.m. period, half of all passengers accessed the bus at bus stops, most likely as transfers from other lines as workers returned home.

Table 10.1. Route 296 Method of Access

	Subscription	*Advance Request*	*Request on Day of Ride*	*Flag Down/ At Stop*	*Total*
AM	54%	6%	9%	31%	100%
Midday	24%	11%	48%	17%	100%
PM	26%	4%	17%	53%	100%

Source. MetroFlex Ridership Summary, August – December 1994

10.6.2 Comparing the Routes

While MetroFlex Route 298 gained in ridership for three years, it did not equal the pace of the ridership gains of Route 296, and it experienced a loss in ridership in 1997. Interestingly, the MetroFlex predecessor routes were at nearly the same average daily ridership in 1992. In that year, Route 296 had 16 percent more average daily riders than Route 298. But by 1997, Route 296's ridership advantage was 133 percent. Other than slight differences in the setup of the routes, such as the greater emphasis on timed connections for Route 296, these differences in performance appear to have arisen from characteristics of the differing service areas.

Both areas have mixes of residential and commercial uses. As noted, populations of the two areas are of similar size. However, the Route 296 area is of higher density at the census tract level.[11] Route 296 also has an advantage in commercial activity, including a large, growing shopping area on the northern end of the route and a small amount of shopping on the southern end. The Route 298 area, on the other hand, has less retail, and has seen some reduction in shopping and a move to higher-end stores. Route 296 also gains ridership from an area school that holds summer sessions, the children from which fill the bus to capacity at times.

Other area demographics vary in their support of the performance trends. The average household income in the better-performing Route 296 area was around $10,000 lower than that in the Route 298 area in 1989. However, much of the difference came from only one high-income census tract within the 298 area.[12] Median household incomes were closer, at about $32,000 for 296 and about $37,000 for 298. The Route 298 area was also significantly more educated than that of Route 296.[13] Possibly related to this, but in contradiction to transit use trends, the Route 296 area had a larger young adult population and smaller senior population than Route 298.

About the same proportions of people in both areas worked in their county of residence. Thus, inter-jurisdictional problems with transit agency linkages should not be a factor in ridership differences. However, persons in the Route 298 service area were much more likely to work in administrative, technical, and sales positions, and less likely to work as administrative support, production, and labor.[14] This contrast might make a difference in transit use due to the locations of these jobs, especially if one area's primary job types are concentrated in the transit-friendly downtown and the other's are not.

These differences make it apparent that factors other than service design affect the performance of MetroFlex routes. While the change to flexible routing appears to have positively affected the performance of the routes, other factors such as demographics and land use are still significant. Adaptive transit solutions like MetroFlex offer ways to better serve suburban areas, but in most instances have not been able to compete with systems which have the advantage of transit-supportive planning and which serve transit-dependent populations

10.7 The Future of MetroFlex

The KCATA has found MetroFlex service a viable service strategy in an increasingly suburban region. The agency plans to expand the MetroFlex system and build on the success of the initial two routes as adaptations to suburban environments. Beginning in January 1999, the agency created a new MetroFlex route near the Route 296 area. The agency was motivated by calls from area residents familiar with the nearby MetroFlex route. Like Route 296, the new route serves a mostly residential area and connects to a shopping mall and to fixed routes.

Political forces will continue to affect the future of flexible routing and other transit innovations in the KCATA service area. For example, the agency redesigned one group of routes in early 1998. One of these routes was a strong possibility for MetroFlex treatment. However, to run through enough political districts to gain support, the route would have been quite long – too long to allow a reasonable level of service. So the agency left the route as a traditional fixed route. In another instance, a proposal for a flex route in one small city was thwarted because the route could not cover the entire jurisdiction.

10.8 Learning from Kansas City

The MetroFlex system has proved to be a successful alternative for transit service in a low-density area. This is important especially in light of the fact that political forces have at times made it impossible to concentrate resources on transit-friendly areas. MetroFlex service is well liked by both riders and drivers. Riders are attracted to the convenience and curb to curb service and the routes' connections to other bus lines. After initial questions, riders seem to understand the system relatively easily, with guidance from the drivers and dispatchers. Many drivers like the system as well, even with the lower pay, for the interaction with customers the service allows. Several drivers have voluntarily come back to MetroFlex after leaving temporarily to drive other routes.[15]

Even with this adaptive, flexible system, the variation in performance between the MetroFlex routes also shows that land use factors remain important. MetroFlex service is more successful in the Route 296 area, which is generally more transit-supportive than the Route 298 area. Thus, while the flexible service can make a difference, it is not a panacea. As always, areas with less need see less use.

One of the strengths of KCATA's system is the agency's use of a combination of service types. The rush-hour route-deviation system allows residents easy access to distant jobs. The midday zoned dial-a-ride system allows flexible routing for intra-area access. Varying the service by time-of-day allows MetroFlex to best serve the preponderance of users at any given time.

MetroFlex also offers a lesson on the appearance of political forces in transit service planning. While older, more dense areas are usually more friendly to transit, the population and political power in many transit districts has moved to the suburbs. When residents of suburban areas feel that they are being underserved by transit, an agency may be forced to allot resources to areas where need and use will not be the highest. It is therefore important to have methods available to serve these areas. And, as more residential areas built with suburban densities and patterns of use are occupied by residents of relatively lower income, transit that can serve them will become increasingly valuable.

Notes

[1] Federal Transit Administration, *Transit Profiles: Agencies in Urbanized Areas Exceeding 200,000 Population, for the 1996 National Transit Database Report Year* (U S. Department of Transportation, Federal Transit Administration, 1997).

[2] Mid-America Regional Council, *Transportation 2020: A Long-Range Transportation Plan for the Kansas City Metropolitan Region* (Kansas City: Mid-America Regional Council, 1995).

[3] Kansas City is extremely well served with roads and freeways Kansas City has 1.25 freeway lane miles per thousand persons, where Dallas-Fort Worth, the next highest city (federal-aid urbanized area) over one million persons, has only 0.9 For all 37 cities over one million population, the average number of freeway lane miles per thousand persons is only 0.6. Kansas City does even better with total miles of freeways per capita; its 0.27 miles per thousand persons is nearly triple the group average of 0 11. And Kansas City leads in total miles of roadway per capita as well. Source: M Teets, ed., *Highway Statistics 1996* (Washington, D C. U.S. Department of Transportation, Federal Highway Administration, Office of Highway Information Management, 1997).

[4] The financial crisis was the result of low tax revenues and federal funding cuts. Source: Jane's Information Group Limited, *Jane's Urban Transport Systems. 16th Edition, 1997-98*, C Bushell ed (Coulsdon, Surrey: Jane's Information Group Limited, 1997)

[5] The areas are both suburban, with residential, some retail, and other uses Populations of the areas are similar, both having about 25,000 residents and 10,000 households in the 1990 U S. Census. Other characteristics vary more significantly between the two areas, as discussed in the evaluation section.

[6] In 1992, average daily weekday ridership for one route reached a high of 55 in January and lows of 36 in September and October. The other pre-existing route reached a high of 46 in January and a low of 33 in December These were the lowest averages in the system except for one other route, which was discontinued in July of that year. Source Kansas City Area Transportation Authority, *Average Daily Ridership* (Internal report, 1992).

[7] MetroFlex consists of routes 296 and 298. KCATA changed the numbers of these routes since MetroFlex service began: Route 296 was formerly Route 196, and Route 298 was 198 For simplicity, we will refer to both routes by their current numbers during all periods.

[8] For instance, one route was changed slightly, based on rider requests, to create a better connection with a fixed-route bus. The agency often does minor "tweaking" of the routes, but major changes are few.

[9] KCATA's planning manager Donna Brown notes that this drop might be explained by several changes in land use in the Route 298 area. One shopping center was converted to a movie complex, several stores moved to higher-end goods, and a restaurant popular with seniors went out of business. Overall, the agency has been more pleased with the performance of Route 296 than Route 298. The agency has studied the routes and made minor modifications to Route 298 to attempt to make its performance more nearly equal Route 296's

[10] While the best comparisons available, these routes (191 and 193) are still not as similar to MetroFlex routes as might be hoped. The routes run through relatively comparable land uses and have similar levels of service and similar economic characteristics. However, both are longer than the MetroFlex routes and operate in different, more mixed land use environments, through the smaller city of Independence,

Missouri. The routes connect more trip generators than MetroFlex routes, and go through Independence's downtown. Routes 191 and 193 also operate on Saturdays, which MetroFlex routes do not. In addition, these routes began by operating at higher levels of productivity than MetroFlex's predecessor fixed routes. By 1997, despite gains in MetroFlex ridership, the productivity of routes 191, 193, and 296 were nearly equal (that of 298 lagged). In that year, routes 191, 193, 296, and 298 had passengers per hour of 8.6, 9.1, 7.4, and 3.2 respectively. For December 1997, direct costs per passenger for routes 191, 193, 296, and 298 were $2 44, $1.34, $1.76, and $3 50, and subsidies per passenger were $1.91, $0.91, $1.42, and $3.21 (direct costs only). By comparison, the system-wide cost per passenger was $1.20, and subsidy per passenger was $0 69. Source: A. Mathena, *System Monitoring Report· December, 1997* (Internal report, 1997).

[11] For tracts near the routes, Route 296 had a density in 1990 of 2,815 persons per square mile, while Route 298 had 1,160 persons per square mile These figures include portions of the tracts that lie outside the MetroFlex service areas and outside convenient walking distance, and so are not entirely indicative of service area density. In addition, the proportion of single-family detached units in the Route 296 area is 73.2 percent, compared to only 52.1 percent in the Route 298 area. These figures seemingly contradict the tract density figures, making it likely that the Route 298 area has more scattered but higher density development. Source: 1990 U.S Census

[12] Average household incomes are about $35,000 for the Route 296 service area and about $45,000 for the Route 298 area. Without the highest income tract in the 298 service area, the difference in average incomes decreases to about $4,500. Source: 1990 U.S. Census

[13] Thirty-four percent of persons 25 and over in the Route 298 have bachelors or graduate degrees, versus 19 percent in 296. Source: 1990 U.S. Census.

[14] 1990 U.S. Census.

[15] Drivers choose routes by seniority.

Chapter Eleven

Free-Enterprise Paratransit: Puerto Rico and Mexico City

11.1 Synopsis

In San Juan, Puerto Rico, Mexico City, and indeed much of Latin America, private minibus and jitney operators have introduced a mix of community-based and subregional services – coordinated through route associations – that fill in the mobility gaps left unserved by mainline publicly operated bus and rail systems. Importantly, these services have gravitated to suburban markets, providing both feeder connections to mainline transit stops and lateral, cross-town services. In both Puerto Rico and Mexico City, paratransit, along with mainline services, closely mimics predominant travel patterns and facilitate intermodal transfers. The resulting transit network very much represents the adaptation of mass transit to spread-out urban landscapes. Institutionally, the arrangements have clear lines of responsibility: governments are the provider of most mainline, high-capacity, and potentially most profitable services, and the private sector largely takes care of branch connections and non-traditional markets. Experiences in Latin America reveal the power of the marketplace, when left to its own accord, to deliver niche services well suited to the lay of the land, and to fill mobility gaps left unfilled by the public sector

11.2 The Paratransit Alternative

Paratransit represents the spectrum of vans, jitneys, shuttles, microbuses, and minibuses that fall between the private automobile and conventional bus in terms of capacities and service features. Often owned and operated by private companies and individuals, paratransit services tend to be flexible and highly market-responsive, connecting multiple passengers to multiple destinations within a region, sometimes door-to-door and, because of multiple occupants, at a price below a taxi (but enough to more than cover full operating costs). Arguably, paratransit represents the most flexible and adaptable form of collective-ride transportation services available

While free-enterprise paratransit exists in a handful of American cities (Miami, Atlantic City, Houston, and New York City), for the most part the sector has been suppressed by protectionist regulations. One need look no farther, however, than America's immediate neighbors to find thriving paratransit sectors – notably, the públicos of Puerto Rico and Mexico City's peseros-colectivos. With commercial trade on the rise in the wake of the North American Free Trade Agreement (NAFTA), and with increased migration from Spanish-speaking to English-speaking parts of the continent, there is today a window of opportunity for exchanging urban transportation lessons within North America. The U.S. has experimented with publicly owned, operated, and subsidized transit services for some three decades now, and almost universally transit is losing market shares of all forms of travel. Finding ways of injecting more competition and greater productivity into America's struggling mass transportation sector is sorely needed. Free-enterprise paratransit represents a promising alternative.

This chapter reviews experiences with free-enterprise paratransit in Puerto Rico (principally the capital city of San Juan) and Mexico City, with an eye toward gleaning policy lessons that are transferable to advanced, industrialized economies like the United States. Experiences in San Juan and Mexico City are relevant to the industrialized world since governments in both places, like nearly all U.S. cities, regulate market entry, pricing, and service practices. However, other institutional initiatives are found in both cities, like pro-paratransit taxation policies and the formation of self-regulating cooperatives, that are rare in the U.S. and industrialized world. In addition to examining regulatory and policy environments, this chapter explores the niche markets served by paratransit in these two case settings and the overall complementarity of commercial paratransit with traditional mainline transit services.

11.3. Puerto Rico's Públicos

Puerto Rico occupies the middle ground between the developed and developing worlds. Officially a commonwealth without statehood status but under U.S. political jurisdiction, Puerto Rico's economy is closely tied to Washington; culturally, however, the island has more in common with the Dominican Republic, Jamaica, and other parts of the Caribbean.

Crowded cities, congestion, and modest incomes have given rise to an extensive paratransit network by first-world standards. With 3.8 million residents inhabiting an island of 3,459 square miles, Puerto Rico's population densities are among the world's highest. San Juan, the island's capital and largest municipality with 430,000 inhabitants (and a metropolitan population of over 1.3 million), has three times more vehicles per lane-mile of road than any city on the U.S mainland. In 1990, half of all inbound directional lane miles on San Juan's major arteries were classified as congested.[1] While Puerto Ricans average the highest per-capita income in Latin America ($3,600 in 1990), they make do with half the per capita income of the poorest American state, Mississippi.

11.3.1 The Público System

Puerto Rico's público system consists of some 12,000 automobiles, vans, and minibuses distributed over around 900 routes throughout the island. The prevalence of licensed públicos is partly a product of history – in the absence of direct government sponsorship of transit, since 1907 the private sector has been the dominant provider of mass transportation services. Though similar to jitneys, públicos actually provide a much wider array of services, including jitney-like intra-urban transport along fixed-routes, door-to-door services within neighborhoods, line-haul intercity travel, and even taxi-pooling. In many ways, "público" defines an organizational approach to paratransit more than a particular type of service. Felipe Luyanda and Podaru Gandhi note: "the fundamental characteristic of the 'públicos' is the institutional arrangement that includes the government incentives and regulations, the route associations, and the high percentage of owner-operators with significant flexibility in the way they operate their businesses".[2] By Puerto Rican law, públicos are considered common carrier vehicles with passenger capacities of 17 or less; larger vehicles are classified as buses.

San Juan's público network is the island's most elaborate. Currently, 2,200 vans and mini-4buses operate over 2,700 route miles of service on 121 designated routes, serving around 195,000 passenger trips per day (i.e., within the metropolitan area). This is more than double the number of passengers served by the 42-route subsidized municipal bus system, Metropolitan Bus Authority (MBA). Still, públicos accommodated only 3.7 percent of all motorized trips in greater San Juan in 1990, down from 7.7 percent in 1976 and 9.2 percent in 1964. MBA's relative standing has fallen even more, serving only 2.4 percent of all passenger trips in 1990, down from 19.6 percent in 1964. Públicos are more popular than MBA buses even though they cost patrons two to four times as much – $0.50-$1 versus $0.25 – per trip Their greater frequency and higher average speeds largely explain why.

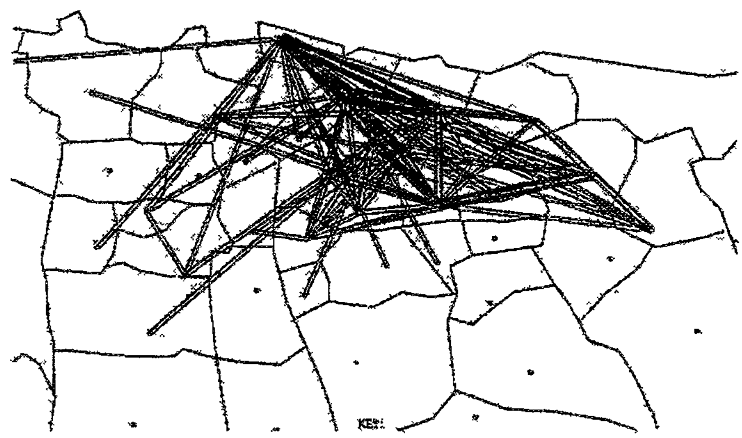
In greater San Juan, públicos focus principally on serving markets outside the core, traditional city. This is mainly because outlying areas have the biggest service gaps. Bayamón and Rio Piedras, two dense town centers south of downtown San Juan (each with around 200,000 residents), together comprise 64 percent of all intrametropolitan routes and 74 percent of the region's público ridership. In both communities, públicos make up over half of all motorized trips to and from their respective town centers. Central Bayamón's públicos average the shortest headways (18 seconds), heaviest loads (13.4 riders per vehicle), and highest revenue intake ($66 per vehicle per day, in 1982 currency) in all of Puerto Rico, and rank among the most productively used vehicles anywhere.[3] These phenomenally short headways reflect the tremendous density of públicos on Bayamón's central routes -- on average, 30 vehicles per route.

Surveys show that as in the United States, most público patrons are captive – over 40 percent are from households with incomes below the island's average and 30 percent are from households without cars. It is because of riders' low incomes that públicos operate at relatively low profit margins. It would be a mistake to characterize públicos' customer base as exclusively captive users, however. Island-wide, around 5 percent of all users are professional workers, and in parts of San Juan (such as the 'Miracle Mile' office corridor in the Hato Rey district), most riders are from middle-class households.

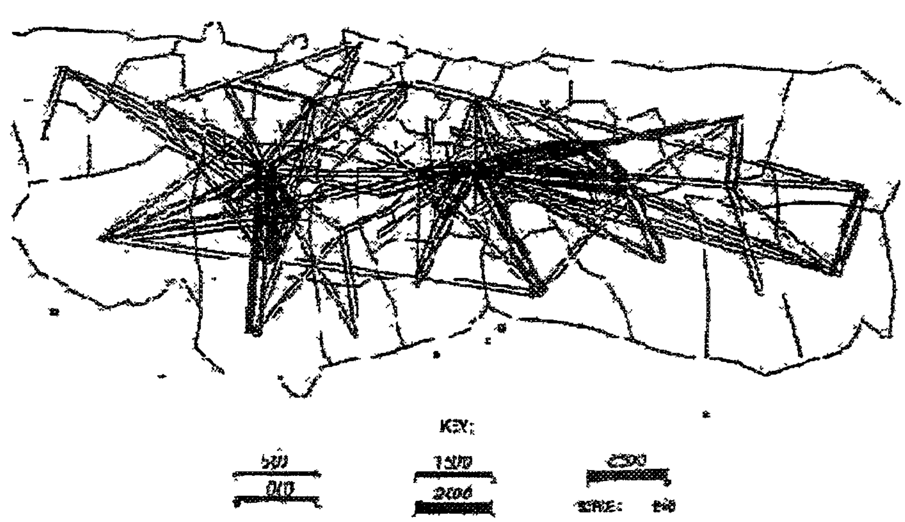
11.3.2 Públicos and Intersuburban Travel

As noted, San Juan's públicos have emerged as essentially gap-fillers, serving neighborhoods and trip patterns neglected by the heavily-subsidized public transit operator, MBA. That públicos and MBA buses serve different markets is partly revealed by statistics on modes of access and egress. In 1990, only 6 percent of access trips to the MBA system and just 2 percent of egress trips (from MBA buses to final destinations) were by públicos. And in terms of access to público routes, MBA buses played even a smaller role. This minimal level of transferring was partly due to an absence of service or tariff integration between public and private transit offerings in San Juan, but mostly because of different spatial orientations. Figure 11.1 clearly shows this. Whereas bus transit desires were predominantly radial and north-south in direction (between the traditional core of Old San Juan and major town centers to the south), trips via públicos were mainly suburb-to-suburb, or east-west in orientation. It is paratransit's natural advantage in serving tangential, cross-town travel that makes it a promising form of adaptive transit.

Origin-Destinations, 1990: BUS TRIPS



Origin-Destinations, 1990: PÚBLICO TRIPS



Source Puerto Rico Department of Transportation and Public Works. *San Juan Regional Transportation Plan*, 1994

Figure 11.1. Comparison of Origin-Destination Patterns for Trips by MBA Buses (top) and Públicos (bottom), 1990

11.3.3 Regulation and Policy5

Públicos are one of the most tightly regulated paratransit industries outside of the U.S. mainland. Puerto Rico's Public Service Commission (PSC) controls market entry, fares, and routes. The only real discretion operators enjoy is when to work; they are not held to any set schedules. By most accounts, PSC is very protective. PSC carefully scrutinizes applications for market entry based on "needs and convenience" assessments and inputs from existing operators. It tends to favor the status quo, especially when incumbent operators feel threatened by new entrants. From 1985 to 1995, the number of público permits island-wide hovered around 11,700-11,900 even though Puerto Rico's population grew by around 8 percent.[4] PSC grants 5-year renewable authorizations and imposes stiff sanctions for such violations as invading another route, operating unsafe vehicles, or unruly behavior. Also involved in the regulation of públicos is the Department of Transportation and Public Works which oversees licensing, vehicle registration, and the construction of terminals and público stops on state roads Local governments regulate the siting of curbside and off-street terminals and stops on municipal roads.

To promote owner-drivers' interests, Puerto Rico's públicos are loosely organized into associations, or what locals call "unions". Unions attempt to rationalize services within a defined territory. They share a common place at terminals (mainly to coordinate vehicles departures), rotate services between vehicles, and sometimes buy tires and parts wholesale. More formal arrangements are cooperatives which pool resources to create operator benefit programs, pay wages to night shift drivers, and coordinate operations.

While the commonwealth maintains tight controls over the paratransit industry, where government policy most differs from that of the United States and other industrialized nations is with regards to policy incentives. In that públicos are the island's dominant form of public transportation and have substantially relieved governments of the kinds of heavy subsidy outlays found in the mainland United States, public policies have sought to reward paratransit entrepreneurs with lower registration fees, excise tax exemptions on vehicle purchases, and low-interest loans. Automobiles in Puerto Rico are much more expensive than on the mainland, with excise taxes adding 20 to 50 percent to the base cost of a vehicle, depending on engine size, weight, and accessories. Operators solely dependent on their público proceeds for income are exempted from excise taxes. Given that San Juan's drivers eke out a modest existence, earning only $150 to $250 per week after expenses, such benefits are crucial to the fiscal viability of público services. With público "medallions" worth as much as $8,000 (by law), operators use them to secure low-interest loans through the Commercial Development Corporation at participating local banks.

Perhaps the most important form of government aid has been the provision of multi-storey terminals near town plazas. Partly funded by grants from the U.S. Department of Transportation, terminals offer vehicle staging areas (first in-first out), facilitate transfers between routes, provide protection from weather, and enhance security and public safety. Equally important, they function as holding pens during slack hours – a safe haven where públicos queue in an enclosed, centralized location rather cluttering the narrow and crowded streets of San Juan and other cities. During peak hours, demand is so high that vehicles need not stack up in terminals. Rather, minibuses pull into staging areas, quickly fill up, and proceed along. The biggest terminals – in Bayamón (681 parking spaces) and Rio Piedras (311 spaces) – are imposing 5-storey structures that dwarf the nearby town centers (Photo 11.1).

In San Juan, a significant challenge in coming years will be to successfully integrate públicos into the city's 19.4-mile, double track, grade-separated rail transit system, Tren Urbano, scheduled to open in the year 2001. By restructuring routes to allow públicos to function like rail feeders, the hope is that eliminating mainline operations along congested arterials will increase average operating speeds and thus ridership productivity of vans and minibuses. Through good planning and careful route design, the inherent complementarity of small-vehicle feeders and high-capacity line-haul services should give rise to efficient travel patterns in greater San Juan.

11.3.4 Contra-Flow Bus Lanes

While not part of the paratransit sector, another element of adaptive transit services in San Juan is the provision of contra-flow bus lanes (Photo 11.2). The 8-mile exclusive bus lane connects the main bus terminal in Old San Juan with the largest público terminal to the south, in Rio Piedras.[5] The contra-flow lane is reserved exclusively for public buses operated by MBA, thus públicos and other private carriers are banned.

In order to create a reserved lane, curbside parking in one direction of San Juan's busiest north-south arterial (Ponce de Leon) was expropriated. Because the corridor is made up of short block faces, with lots of crossing traffic that blocks through lanes, engineers felt an opposite-flow lane stood the best chance of maintaining high-quality bus services. Because motorists risk head-on collisions if they stray into contra-flow bus lanes, lane violations are infrequent and bus flows are largely immune to surface-street congestion This has enabled buses to achieve relatively high speeds and on-time service delivery, earning counter-flow services the name of "Metrobus". Counter-flow services are the most productive bus operations in San Juan, capturing nearly a third of MBA's patronage (though accounting for less than 12 percent of the system's vehicle miles). Besides fast speeds and punctuality, the success of Metrobuses also lies in the frequency of service – most routes plying along the contra-flow lane are on 4 to 5 minute headways during daylight hours. The presence of dense activity nodes along the exclusive bus lane justifies frequent services.

11.3.5 Contrasting Paratransit in Puerto Rico and the United States

Because of públicos' sheer dominance as a mass transport carrier throughout the island, government protections to ensure minimum travel needs and public safety standards are met has become even more imperative than in the mainland United States. Today, Puerto Rico's paratransit regulatory environment is even more restrictive than in U.S. mainland cities like Miami and Atlantic City, and more recently, Houston and Indianapolis. However, where the commonwealth distinguishes itself from the U.S. mainland is in providing fiscal incentives and infrastructure specifically targeted at paratransit entrepreneurs. Consequently, its policies have made público-riding a bargain relative to the cost of owning and using a car. And by providing convenient terminals and staging areas, públicos operate efficiently without drawing the consternation of and political backlash from middle-class motorists who might otherwise be paralyzed by swarming vans and minibuses. It has been through striking this balance between government oversight and promotion

Photo 11.1. San Juan's Públicos, stacked at a multi-story terminal in Bayamón.

Photo 11.2. Contra-Flow Buses Along San Juan's Main North-South Arterial Axis

that públicos remain an important part of the local transportation scene. While paratransit in Puerto Rico has lost market shares to the private automobile, worsening traffic conditions and the emergence of mainline rail services in San Juan promise that it will continue to serve a healthy market niche.

11.4 Mexico City's Peseros and Colectivos

As the world's largest metropolis, with estimated population as high as 22 million, Mexico City poses mobility challenges that are unparalleled. The Federal District, the 500-square-mile administrative area that makes up the national capital, claims a more manageable 8.5 million inhabitants. However, with population having nearly doubled every decade since 1930, urban growth has in recent decades spilled well beyond the Federal District into the surrounding State of Mexico It is the Federal District and its adjoining suburbs that make up the megalopolis of Mexico City, with an official 1990 population of 15.1 million and an unofficial one of well over 20 million. Today, about one quarter of Mexico's population resides in greater Mexico City, which covers just 1 percent of the country's surface area.

Over 37 million motorized trips are made each day within metropolitan Mexico City, 70 percent occurring within the Federal District. Nearly 3 million private automobiles are registered in the metropolis, and vehicle ownership has risen at least twice as fast as the region's 2.5 percent annual population growth rate. During peak hours, traffic within the District crawls at an average speed of 9 kilometers per hour. The crush of automobiles has produced some of the worst smog conditions anywhere, exacerbated by mountains that ring the valley and contain pollutants. The Federal District has imposed a "Days off the Road" scheme which restricts private and government vehicles from operating at least one day a week, on a rotating basis, according to the last digit of license plates.

Mexico City's congestion and pollution would be much worse were it not for the dynamic and wide-ranging transportation system that has evolved over the years in response to explosive growth. Notably, a hierarchy of transportation services – both public and private – has emerged, providing a rich mix of travel options in terms of geographic coverage, vehicle carrying capacities, and levels of integration. At the top of the hierarchy and forming the backbone of the network is Metro, whose 9 lines criss-cross the District, totaling 158 kilometers of guideway and 135 stations. With average peak-hour headways of around a minute and daily ridership nearing 5 million, Metro is one of the most extensive and highly patronized rail transit systems in the world (larger in size and claiming more riders than all others metros in Latin America – São Paulo, Rio, Caracas, Santiago, and Buenos Aires – put together). Around one in five daily trips made within the District use the Metro for at least one leg.[6]

With Metro forming the main arteries of the region's transit network, equally vital to the lifeblood of the metropolis have been the network's capillaries – the extensive system of paratransit feeder services known locally as peseros and colectivos. In the 1950s, taxi drivers operating along the city's busiest boulevards began augmenting income by picking up multiple unrelated passengers, charging them a flat fee – one peso. The mode quickly grew in popularity and became known as a pesero. As peseros increasingly became the public transportation mode of choice, taxi sedans were gradually replaced by Volkswagon vans, also known as combis, during the sixties and seventies. Today, combis are being replaced by 23-seat minibuses which burn unleaded fuel. The name "colectivos" generally refers to these larger minibuses.

11.4.1 Paratransit in Mexico City: A Market Adaptation

Peseros and colectivos grew and adapted throughout the 1970s and 1980s in response to the rapid expansion of the Metro system. What has evolved is a hub-and-spoke transport network that closely mimics predominant travel patterns and facilitates transfers. Institutionally, the arrangement has clear lines of responsibility – government is the provider of mainline services and the private sector takes care of branch connections. However, supplementing the private paratransit sector, though more in the background, have been several publicly supported surface transportation modes – notably, the Ruta-100 bus network (recently returned to private concessionaires), 19 trolley buslines, and the 30-kilometer Tren Ligero light rail system. Hierarchically, these public surface routes function more as distributors, filling in mainline service gaps of the Metro and serving more intermediate-distance trips.

The hierarchy of paratransit services in greater Mexico City is further revealed by Table 11.1. Taxis provide on-call, curb-to-curb services whereas other paratransit modes ply principal routes. Pesero sedans tend to serve the lowest-volume corridors and make slight route detours at riders' requests. Combis normally carry 2 to 3 times as many riders as sedans, and concentrate mainly on intermediate-volume markets in the suburbs. Minibuses seat up to 25 passengers with room for an equal number to stand. Table 11.1 also shows that vehicles have segmented themselves out geographically, with smaller vehicles serving shorter-haul customers (more often in the suburban-exurban fringes of the State of Mexico) and larger vehicles traversing longer distances (more often within the Federal District). Overall, market segmentation by vehicle capacity and corridor has helped to rationalize the use of scarce road space.

Table 11.1. Mexico City's Hierarchy of Paratransit Services, 1994

	Typical Route Seating Capacities (No. of Passengers)	Operating Ranges (Oneway Kilometers)	1994 Vehicle Inventory		
			Federal District	State of Mexico	Total
Taxis	2-3	3-6	56,059	8,456	64,515
Peseros Sedans	5-6	2-4	763	2,626	3,389
Peseros VW Vans	10-14	5-10	22,690	13,860	36,550
Colectivos: Minibuses	22-25	10-20	20,493	9,527	30,020
TOTAL	--	--	100,005	34,469	134,474

Source Comision General de Transporte, 1994, field surveys, 1994

Presently, there are around 100 paratransit routes in Mexico City, and each route averages around 15 deviations or branches. Thus, there are some 1,500 derivations among the 100 or so main paratransit routes. Central Mexico City is virtually saturated with peseros and colectivos during peak periods. Middle-class suburbs are also well served. Many barrios and slum areas on the periphery receive thinner services, not only because their residents are less able to pay market-rate fares but also because roads leading to these areas are often poor and steep. The routes of nearly all peseros and minibuses in the surrounding State of Mexico end at a Metro terminal station (Photo 11.3).

Photo 11.3. Minivans serve a terminal station of Mexico City's Metrorail System

On the demand side, paratransit reigns supreme among all forms of travel in greater Mexico City. Table 11.2 shows that colectivos, peseros, and taxis combined to handle around 40 percent of motorized trips in the Federal District and 37 percent of trips in the State of Mexico in 1994. Paratransit was more heavily patronized than all public transit combined in the Federal District and carried comparable loads as motor buses in the State of Mexico. Combining demand and supply figures (i.e., from Tables 11.1 and 11.2) reveals that the average daily passenger load of a colectivo operating in metropolitan Mexico City is around 280. Average daily peseros ridership is 120 passengers per Volkswagon van and 65 passengers per sedan.

Mexico City's paratransit sector also plays a dominant role in getting patrons to and from Metro. According to preliminary origin and destination survey data compiled by the Comision General de Transporte (CGT), approximately ten times as many people access the Metro via paratransit as they do by walking. A significant share are middle-class professionals and government workers.

Together, metro and its paratransit feeders have dramatically increased accessibility to the urban edge, home to millions of rural immigrants and poor households. This is the fastest growing travel market, one well suited to paratransit services Decentralization has resulted in exceedingly long average travel times – in 1994, 46 minutes for the region a whole and 53.5 minutes for those residing outside the Federal District.[7]