



## Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services

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**TCRP REPORT 116**

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**Guidebook for Evaluating,  
Selecting, and Implementing  
Suburban Transit Services**

URBITRAN ASSOCIATES, INC.  
New York, NY

IN ASSOCIATION WITH

CAMBRIDGE SYSTEMATICS  
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Portland, OR

PITTMAN & ASSOCIATES  
San Francisco, CA

CENTER FOR URBAN TRANSPORTATION RESEARCH  
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**TRANSPORTATION RESEARCH BOARD**

WASHINGTON, D.C.  
2006  
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The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions*, published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

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The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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**Gwen Chisholm**, *Senior Program Officer*

**Eileen P. Delaney**, *Director of Publications*

**Beth Hatch**, *Editor*

## **TCRP PROJECT B-25 PANEL FIELD OF SERVICE CONFIGURATION**

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**Murthy V. A. Bondada**, *Atlantic Transportation Engineers, Inc., Winter Garden, FL*

**Edmond Chin-Ping Chang**, *EDCPC, Inc., Potomac, MD*

**Steven R. D'Antonio**, *Southeastern Pennsylvania Transportation Authority, Philadelphia, PA*

**Catherine C. Dennis**, *Delaware Transit Corporation, Wilmington, DE*

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**Mark I. Pritchard**, *Dutchess County Loop, Poughkeepsie, NY*

**William Wiggins**, *FTA Liaison*

**Peter Shaw**, *TRB Liaison*

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Marlene Connor, Senior Vice President Transit Services, Urbitran Associates, Inc., was the principal investigator. The other authors of this report are Jim McLaughlin of Urbitran Associates, Chris Kopp of Cambridge Systematics, Paul Ryus of Kittelson & Associates, Donna Pittman of Pittman & Associates, and Joel Volinski of CUTR.

# FOREWORD

By Gwen Chisholm

Staff Officer

Transportation Research Board

*TCRP Report 116: Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services* examines the current status of suburban transit services and land-use environments and the relationship between the two. Types of suburban transit services include commuter, route deviation, demand response, circulators, shuttles, and vanpools. Also, the guidebook describes the emerging trends that significantly influence the availability and operation of suburban transit services.

This report updates information presented in *TCRP Report 55: Guidelines for Enhancing Suburban Mobility Using Public Transportation* and presents the latest research results and issues related to suburban transit services. This information will be useful to transit professionals and policy makers in planning and implementing suburban transit services.

The companion document to the guidebook is a final report that includes eight detailed case studies: Suburban Mobility Authority for Regional Transportation (Detroit, Michigan); Metropolitan Council and Minnesota Valley (Minneapolis/St. Paul, Minnesota); Tri-Met (Portland, Oregon); South Metro Area Rapid Transit (Wilsonville, Oregon); King County Metro (Seattle, Washington); Capital District Transportation Authority (Albany, New York); Broward County Transit (Broward County, Florida); and Regional Transit District (Denver, Colorado). The case studies describe the types of suburban transit services offered; the types of operational issues; the funding arrangements; the marketing program; the performance-measurement program; and the successes, challenges, and lessons learned from introducing suburban transit services. The companion report also includes quantitative and qualitative decision matrixes. The companion report is available online as *TCRP Web-Only Document 34* at [http://trb.org/news/blurb\\_detail.asp?id=6526](http://trb.org/news/blurb_detail.asp?id=6526).

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During the past 30 years, new suburbs have emerged at greater distances from central business districts. These suburban land-use environments have not generally been conducive to provision of transit services. However, suburban areas are changing dramatically: the suburban population is becoming more economically diverse, the aging population is increasing, and the transit-dependent community is growing. Consequently, the need for suburban transit services has grown.

In past years, transit districts have introduced a variety of transit services in suburban neighborhoods, including vanpools, dial-a-ride, shared-ride taxi, flex service, neighborhood circulators connecting with fixed-route service, and extended fixed-route service. The success of these services has varied. Information on the most effective methods of serving suburban needs can be used by the transit industry to improve market share and productivity in the biggest potential market area—the suburbs.

In the years since publication of *TCRP Report 55*, land use and its relationship to transit services has changed as contemporary suburbia has extended beyond the older suburbs. The research confirmed that the land-use connection with suburban transit services is primarily based on local policies, which are substantially influenced by the availability of local funding.

This report provides updated information and guidance on the latest developments in suburban service options and attributes.

Urbitran Associates, Inc., in association with Cambridge Systematics, Kittelson & Associates, Pittman & Associates, and the Center for Urban Transportation Research, reviewed trends and developments of suburban transit services and recent land development. The research team identified and described suburban land-use environments and appropriate transit service strategies; established a methodology with evaluation criteria to determine best practices in providing suburban transit services; conducted the approved case studies; and documented the success and the lessons learned regarding the provision of suburban transit services.

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## CHAPTER 1

# Introduction to Suburban Transit Services

### Overview

An overriding thesis of the modern condition is that mobility is becoming increasingly complex. Nationwide, economic growth has led to commercial expansion reaching farther and farther out to suburbia, creating more settings to which the transit industry has been asked to respond. These suburban communities are creating less dense, more auto-dependent environments. For the transit industry, these types of communities have been historically the most difficult to serve because they lack the density to support fixed-route and lack the finances to support demand-responsive services. Because of the increasing fuel prices and the continuing demand from constituent groups (such as older adults) to provide more mobility options, the need exists to revisit the state of the practice in the delivery of suburban services.

The typical trip purposes that are served by suburban transit services include long-distance commute, connections to the regional transit network, and intracommunity connections. A large percentage of the suburban services provided in the preliminary and detailed case study sites were developed to offer service in areas with relatively low demand for transit. These services included both fixed-route and demand-responsive services. Many of these services, especially route-deviation and demand-responsive, focus on providing area coverage, but they also provide connections to the regional bus system. The increase in population and development in new or growing suburban areas has also resulted in an increase in commuter services in corridors that access those suburban areas, especially commuter bus services. As a result, the typical suburban system today includes local, regional, and commuter services.

As will be discussed, although there has been much work in the transit industry to wrestle with the difficulties of suburban transportation, including developing a long list of innovative, technology-enhanced services, there are no “one size fits all” solutions. Although emerging databases and resources can be used to assist transit agencies in planning

land-use connections, the lack of availability and lack of consistency of these resources limit their applicability. Further, in the detailed case studies, neither the land use nor the transit data suggest specific approaches to predicting efficiency or effectiveness, though the trends described can provide guidance in the development of such services.

As was found to be the case in the original research, determining the success of suburban transit services remains ultimately a policy-related task. Success appears to be measured in a wide variety of ways at the local level, which will be discussed as part of the guidebook. The policy perspective regarding the success or failure of many suburban services is often not based on typical quantitative performance measurement factors, but rather on qualitative concepts, such as value added to the community. These findings suggest that although suburban transit service delivery remains more of an art than a science, the combination of innovation and technology—including the use of geographical information systems (GIS) incorporating land-use data—may lead to more uniform solutions in the future.

### Summary of Findings

The goals of this research were to examine the current status of suburban transit, from both operations and land-use perspectives, and to develop guidelines for evaluating, selecting, and implementing those services. The guidelines would be in the form of a guidebook that would inform both technical staffs and policy boards. The research was conducted by a multidisciplinary team and included evaluation of approximately 30 preliminary and 7 detailed case studies. The evaluation included substantial communication and understanding of those preliminary and detailed case studies and was compiled in the findings and conclusions of the research.

Unlike some research efforts that focus on the mathematical formulas associated with specific public transit issues, this research, as will be described more thoroughly below, reinforces

the importance of public policy decisions within an area that is still developing. These policy-related perspectives, combined with the technical results of other research, yielded the following findings:

- The state of suburban transit services continues to evolve just as the state of suburbs also evolves. For example, as suburbia extends into new areas, the formerly suburban areas begin to resemble the downtown areas of decades ago, thereby further stretching the resources required to adequately connect those new suburban areas with public transit.
- Although the menu of solutions (commuter service, regional connection, and local circulation) remains similar from prior studies, the decision-making process to retain or withdraw these suburban services is primarily based on local policies, which are substantially influenced by the availability of local funding.
- Measurement processes for these services can also vary from a relatively stringent, quantitative analysis (e.g., meeting a minimum ridership-per-hour threshold) to a less stringent, qualitative analysis (e.g., maintaining community control of local circulators). Denver Regional Transportation District (RTD) uses a modified performance level evaluation for all of its suburban transit services. This evaluation can serve as a model for other agencies to consider and will be described in detail in the guidebook.
- Efforts by the research team to more specifically analyze the land-use connection with suburban transit services provided mixed results. The research team found that the use of information on density, diversity, and design components had potential to assist with transit planning at the local level, but not at the national level. Because the land-use data were inconsistent and difficult to assemble into a uniform format, and because the attributes of the services varied greatly from location to location, it was not possible to develop a comparative analysis that could be used in general throughout the country. In fact, several research team members believed that further national collection of those specific land-use data (e.g., percentage of persons employed in manufacturing) would not expand the value of those data, and perhaps the best incorporation of land-use data would be at the local level as recorded and analyzed at the local level.
- It appears that more agencies are grappling with the issue of how to provide services in areas that cannot support fixed-route services. Some options, such as point and route deviation, appear to be accepted by local communities in some areas but not accepted by others. One increasingly implemented option is to expand the role of demand-responsive services, many times requiring order taking and real-time scheduling by vehicle operators.
- It also appears that many of the alternatives to fixed-route services are developed with the goal of expanding suburban transit service coverage, which is sometimes counter to the goal of fixed-route services, which is to maximize productivity. Some of the alternative services eliminate the need for delivering separate Americans with Disabilities Act (ADA) complementary paratransit services by blending ADA-eligible clients into the suburban service solutions.
- Additional research may prove beneficial by focusing on non-fixed-route options and the potential to coordinate human service transportation (as exemplified by the Federal United We Ride program) with options for ADA paratransit. Although the demand for ADA paratransit service has increased significantly in both urban and suburban locales, the cost of the service is outpacing the funding sources.
- Although the specificity of land-use data and the uniformity of suburban transit data were not as good as the research team originally anticipated they would be, there appear to be various general trends and conclusions that will increase the understanding of the complexities of suburban transit services and underscore the importance of the local policy-making process.

This research did not result in easy-to-adapt findings or concrete guidelines because many aspects of public transit service delivery, whether from the planning perspective or policy perspective, remain more art than science. However, the findings of this research will still help policy boards better understand service options and attributes. The research ultimately identified several applicable traits that can help transit agencies think about the issues involved in suburban transit services.

The final report for this project is available online as *TCRP Web-Only Document 34* at [http://trb.org/news/blurb\\_detail.asp?id=6526](http://trb.org/news/blurb_detail.asp?id=6526).

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## CHAPTER 2

# Tools, Techniques, and Technology for Suburban Service Development

### Understanding Regional Activity Patterns

The urban form of modern cities and contemporary suburbia is increasingly characterized by multiple activity centers. The polycentric city is a complex hierarchy of centers, corridors, and areas in between. Whereas a large share of trips in the pre-automobile city went radially to and from the downtown, the modern city is characterized by dispersed travel patterns in all directions. This is evidenced by the continuous rise in suburb-to-suburb travel over the last few decades.

The initial step in designing such a regional transit system involves understanding the intrinsically related patterns of development and travel demand. Travel demand is the sum of the individual trip origins and destinations of every traveler in the region. While this information can be represented in large trip matrices, as is done in travel demand models, a useful method for visualizing regional development patterns and travel demand is to analyze the activity surface.

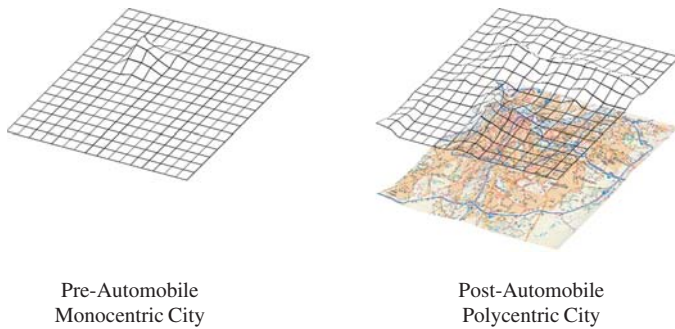
As illustrated in Figure 2-1, an urban area can be thought of as a surface that represents the relative importance of each point across the metropolitan region. The relative importance of a point is a function of the number of activities that serve as the ends of trips, such as jobs, shopping, medical care, recreation, and housing. The activity surface of a pre-automobile city was a relatively simple convex surface with a noteworthy peak over the downtown, a single mountain in a large plain. The modern, polycentric city has a much more complex, bumpy activity surface characterized by peaks of various heights over the traditional downtown and outlying centers, ridges connecting peaks along major corridors, and plains in between, where people live in sprawling subdivisions.

Supported by tools such as the activity surface, this project explores the relationships between the land-use characteristics and travel patterns of the service area, the operating characteristics of the service, and the service's performance in a range of suburban environments. These relationships provide

guidelines that transit operators and policy makers may use to inform their decisions on where to operate service and what characteristics the service should have, given different performance expectations.

*TCRP Report 55* identified six types of suburban land-use environments based on their diversity of uses and how the intensity of their development (i.e., density) relates to that of the surrounding area. These environments included residential suburbs, balanced mixed-use suburbs, suburban campuses, edge cities, suburban corridors, and exurban corporate enclaves. Thinking back to the discussion of the activity surface, each topographical feature of the activity surface corresponds to one or more of these suburban environments:

- **Peaks** represent the major activity centers, such as downtowns, shopping centers, edge cities, and community business districts. In a polycentric city, peaks have various heights based on their relative share of the region's total residential, employment, commercial, medical, and recreational activity. Edge cities and downtowns of balanced mixed-use suburbs are examples of peaks. Peaks generally have urban characteristics, such as a diversity of uses, higher densities, and perhaps deterrents to driving.
- **Ridges** represent the major travel corridors in a region. These corridors frequently connect peaks and are often lined with higher-density residential, employment, or commercial uses. Suburban corridors are examples of ridges. Ridges have more suburban qualities, such as less diversity and large gaps in the street wall, although there may well be deterrents to driving in the form of traffic congestion.
- **Points** represent places in the region that are destinations for trips, but that do not necessarily fall on peaks or ridges. Suburban areas are characterized by a relatively high share of destinations that are not located within walking distance of other major activity centers or on major transportation corridors. Suburban campuses and exurban corporate



**Figure 2-1. Conceptual activity surfaces by urban form.**

enclaves are examples of points. Points are largely characteristic of suburbs, without the qualities of urban areas.

- **Plains** represent the large areas of relatively low-density residential, office, or industrial development that frequently serve as one end of a trip. Residential suburbs are an example of plains. Like points, plains are largely a phenomenon of suburbia and do not have high diversity, density, or deterrents to driving.

## Features of Suburban Transit Services

As suburbs expand and the suburban population grows, it is increasingly apparent that traditional transit service is often not suited to meet suburban mobility and accessibility needs. In spite of significant investments in transit services, transit's mode share is challenged overall, even for commute trips, which are often perceived as transit's biggest market. As discussed previously, the private automobile offers the convenience and flexibility that many people often take for granted in their daily travels. However, congestion, fuel costs, mobility needs of the transportation disadvantaged, and environmental concerns require that alternatives to private automobiles and driving alone be viable and available.

With a commitment to providing transportation options in suburban locations comes the understanding among public decision makers and transit agencies that traditional transit options may not be effective and must be redefined to better serve suburban markets. Traditional fixed route may not meet passengers' mobility and accessibility needs. Therefore, there needs to be a commitment to try new things and develop new ways to provide transit that offers benefits similar to automobiles. Benefits of private cars, and consequently desirable attributes of suburban transit, include

- Near door-to-door service,
- Flexible routing and scheduling,
- Service on demand,

- Relatively fast trips,
- Real-time information,
- Comfort, and
- Convenience.

In order to provide these attributes in suburban transit service, transit agencies must develop transportation solutions that are tailored to the specific circumstances of the service area. Services must reflect the transportation needs of the community, the operating environment, and demographics.

## Established Suburban Transit Services

### Fixed Route

Among the most commonly deployed transit services, fixed routes are routes that follow a predetermined alignment and schedule. Fixed routes may operate more frequently than other service forms and provide service during peak hours or all day. Fixed-route services include

- Trunk,
- Express,
- Limited service,
- Circulators, and
- Shuttles and feeders.

### Deviated Fixed Route

In deviated fixed-route service, vehicles have the flexibility to move within a given service area as long as they arrive on schedule at various time points. Often the time points are located at transit hubs where passengers can transfer to trunk or express service. Deviated fixed routes frequently use smaller vehicles, whether they are small buses or large vans. It is also common for these routes to have their own identities, with unique logos and color schemes.

Deviated routes generally take one of three forms. The most flexible form of deviated fixed route is essentially a demand-responsive service that has two time points, one on each end of a service area. A slightly more restricted service might have a vehicle running along a route between four or five time points, but deviating as necessary for passengers to board and alight. Another common variation is to have a vehicle follow a fixed route, but allow it to deviate up to a given distance (typically one-half or three-quarters of a mile) from the route to pick up or drop off passengers. Examples of deviated fixed-route services include

- Circulators and
- Shuttles.

### *Demand-Responsive Service*

Demand-responsive service, also called “dial-a-ride,” schedules vehicles to pick up and drop off passengers throughout a service area, providing high-quality, curb-to-curb service for the general public and persons with disabilities. These services are particularly effective in areas with low-density development and/or widely dispersed trip generators that are hard to serve with a fixed route or full-size coach. All of these trips require a call-in request. Advance notice requirements vary from days in advance to the actual time of the desired trip. Demand-responsive services use smaller vehicles—small buses, large vans, or taxis—which can navigate residential neighborhoods and narrow streets.

Because of smaller passenger loads, vehicles can follow more direct routes between origins and destinations, thereby reducing trip travel times. Technological advances, including improved dispatching capabilities and real-time information, should allow transit systems to significantly reduce advance reservation requirements.

Similar to the deviated fixed-route service described above, demand-responsive service is generally provided as shuttle, feeder, or circulator service. Demand-responsive service is probably most commonly associated with social service transportation and is also used to meet the paratransit requirements of ADA. In the private sector, airport shuttles are probably the most common application of demand-responsive service. In the overall network of suburban transit services, demand-responsive service plays a critical role in serving niche markets that are not well served by fixed-route service and appears to be positioned to increase its relative profile in coming years.

### *Subscription Service*

Subscription service offers a tailored transit service to specific individuals when they have paid a subscription fee. Many subscription services originated as private enterprises and have transitioned to public operation, although they may also be the result of a public-private partnership. Subscription vehicles, whether they be coaches or smaller vehicles, collect passengers at predetermined times and locations. Trips are scheduled to best meet the needs of a particular trip’s passengers in terms of the origin, destination, and pick-up and drop-off times. Subscription services tend to operate from residential areas that have low average densities but have concentrations of residents who have similar work locations. Subscription services often experience farebox recovery ratios much higher than other transit services because the demand for service is known in advance and because such a premium service demands higher fares.

For the purposes of this document, the discussion of subscription services is limited to commute service because this

is the market upon which most public and public-private partnerships focus. However, it is worth noting that other subscription services exist for markets such as childcare, sporting events, and travel to airports. The most common examples of public subscription services are commuter buses and vanpools. Although some ADA trips are called “subscription” trips because they involve a standing reservation for a particular trip made by a specific passenger, they are not included in this discussion. Rather, these trips are classified as being part of demand-responsive service. Examples include

- Subscription commute buses and
- Vanpools.

### **Innovative Suburban Transit Service**

Innovations in technology have also led to innovations in various aspects of suburban transit services. These include the availability of real-time information to assist both customers and service providers with schedule adherence, operating conditions, and so forth. In demand-responsive services, real-time scheduling and dispatch programs can improve efficiency and effectiveness. Some systems have employed the use of cell phones to ensure more direct communication between customers and operators. Smartcards have become another means of improving transfers between systems and services while reinforcing the goal of seamless travel. In addition, vehicle design features, such as low-floor buses, have made accessing the vehicles easier for all age groups, and automated stop announcements have assisted in the consistent availability of this information for people with disabilities. Examples include the following:

- Technology and infrastructure improvements,
- Real-time information,
- Transit preferential treatment,
- Vehicle modifications, and
- Fare technology.

### **Transit Services and the Activity Space**

The previously described activity surface provides the basis for relating the spatial distribution of travel demand and the optimal arrangement of transit centers, line-haul routes, and other transit services. All transit services can be organized around the topographical features on the activity surface, as shown below:

- **Peaks** are generally the best locations for transit hubs because the concentration of routes serves travel demand from all directions and because the concentration of trip ends minimizes the need to transfer. Peaks are the largest

destinations for travel by all modes and are generally served by the highest-frequency, highest-capacity transit services in a region.

- **Ridges** are generally the best locations for traditional line-haul transit services, including rail and fixed-route bus services, since they have a relatively high number of trip ends within walking distance and since the mix of uses provides a source of relatively high, all-day travel demand.
- **Points** are among the most difficult locations to effectively serve with fixed-route transit. Not only are points geographically dispersed, but their travel demand also tends to be concentrated at certain times of day. As a result, these places tend to be poorly served by transit. Frequently, they receive little or no service at non-peak times, are served by dedicated trips or scheduled route deviations that can confuse customers, or require customers to walk a long distance to a mainline bus route.
- **Plains** are also notoriously difficult to serve with fixed-route transit because of the low density, the coarsely grained mix of land uses, and the lack of well-connected pedestrian facilities frequently found in suburban residential areas.

### Land-Use Assessment

In assessing the land-use conditions within the transit service areas, the research team considered the “four D’s”: density, diversity, design, and deterrents to driving. These measures were chosen in order to evaluate the level of transit supportiveness of each service area.

### Density

The density indicator was measured by calculating the number of people, households, and employed people in the study area. Data were most often available at the traffic analysis zone (TAZ) level provided by the metropolitan planning organization (MPO) in that region. In some cases, particularly for numbers of people and households, data were provided in different units of geography, such as census tracts.

### Diversity

To assess the diversity of activities occurring in each service area, the research team evaluated the mix of industries and land uses present. Industry data on employment in each service area, when available from MPOs or other sources, were summarized and presented as well. Land-use data in GIS format were also obtained from MPOs, at times at the parcel level.






**Table 2-1. Rating system for sidewalk coverage.**

Rating	Criteria for planners	Criteria for laypersons
1	Most streets do not have sidewalks.	A person cannot walk there; he/she must use the street.
2	Many streets do not have sidewalks—there are many gaps in sidewalks.	It is difficult to walk there—there are lots of gaps in the sidewalk.
3	There are sidewalks on at least one side of most streets.	A person could walk there but it would not be very easy or pleasant.
4	There are sidewalks on nearly every street, but not always on both sides.	It is fairly easy to walk there but there are some places where it could be improved (e.g., crosswalks, lighting needed).
5	There are sidewalks on both sides of nearly every street.	It is very easy to walk there (extensive sidewalks, crosswalks, pedestrian crossing lights).

### Design

Design was measured in terms of sidewalk and street connectivity and whether the area would qualify as an “urban place.” Sidewalk connectivity was chosen as an indicator of the ability for pedestrians to walk to transit stops. This was evaluated on a scale of 1 to 5, with 5 indicating the highest level of sidewalk coverage. As shown in Table 2-1, the numerical measures are correlated with descriptions from the perspective of a pedestrian or a planner, depending on the training level of the rater.

**Table 2-2. Rating system for street connectivity.**

Rating	Description	Aerial View
1	Very low level of street coverage; mostly a few collectors or arterials with a few cul-de-sacs.	
2	Cul-de-sacs and curvilinear roads predominate; there are few areas with grid coverage.	
3	Significant grid coverage but also a number of areas with cul-de-sacs and dead ends.	
4	Extensive grid network with a few cul-de-sacs and dead ends.	
5	Complete grid network with no cul-de-sacs or dead ends.	

The street network was evaluated for its level of connectivity to determine whether transit riders would have options for direct routes to transit stops. This rating was also done on a scale of 1 to 5, with greatest connectivity being a 5. Images of sample street networks for each of the five levels were chosen to give raters a visual reference. Additionally, a text description characterizing each level of connectivity was used as a guide, as shown in Table 2-2.

The final element of the design measures was evaluating whether a suburban service area included any places that could be characterized as urban in terms of development patterns, street space, or walkability. This was a yes/no evaluation of whether the study area has a place with buildings fronting on the street and defining a strong public space, such as a traditional “Main Street.” If the person evaluating the area could answer “yes” to all of the following questions, the area was determined to have a place with “urban” characteristics.

- Does the service area include a place where most buildings are adjacent to the sidewalk, not set back from the sidewalk?

- Does the service area include a place where there are few, if any, parking lots in front of buildings?
- Does the service area include a place where there is high street wall continuity—a place where buildings are lined up next to each other with few gaps, providing a vibrant place for pedestrians to walk?

### **Deterrents to Driving**

Deterrents to driving are characteristics of a service area that have the potential to encourage more people to choose transit over driving. The research team evaluated two measures: parking costs and transit priority features. Parking costs were defined in terms of average daily cost of off-street parking. If the study area included a place where free parking is generally not available, the value of this binary value was defined as “yes.” Transit priority features include traffic signal priority, queue jump lanes, exclusive transit lanes, or busways. The transit priority features measure was reported as either “yes” or “no” depending on whether the suburban transit service made use of any of these features.



## CHAPTER 3

# Preliminary Case Study Findings

This chapter outlines the findings from preliminary case studies completed for 28 transit operators. These preliminary case studies served multiple roles:

- They confirmed the range of transit service formats operating in suburban environments.
- They helped the research team understand how agencies evaluate the performance of their transit services.
- They helped the research team identify key issues and trends facing suburban transit.
- They provided the data for the activity surface analysis and the land-use analysis. These analyses compared the characteristics of transit service with characteristics of the suburban land form, focusing on the four D's of density, diversity, design, and deterrents to driving.

A number of techniques were used to select sites for the preliminary case studies. These techniques included reviewing transit agency websites, identifying appropriate sites from the literature search, requesting information via a list-serv, and applying the professional knowledge of the research team regarding various transit properties. From the preliminary case studies, select case studies were chosen for detailed analysis. The final choice of detailed case study locations was done to balance the size and geographical coverage of agencies, while ensuring that unique programs were also included.

Following is a list of the 28 transit agencies that were part of the preliminary case studies. The list is organized first by geographic region (West, Midwest, South, and East) and then by agency size (starting with the smallest agencies).

### West:

1. Livermore Amador Valley Transit Authority (LAVTA, in California)
2. South Metro Area Rapid Transit (SMART, in Oregon)

3. Eastern Contra Costa County Transit Authority (Tri Delta Transit, in California)
4. Orange County Transportation Authority (OCTA, in California)
5. Pierce Transit (in Washington state)
6. Valley Metro (in Arizona)
7. Metropolitan Transit Development Board (MTDB, in California)
8. King County Metro (Metro, in Washington state)
9. Denver Regional Transit District (Denver RTD, in Colorado)
10. Tri-County Metropolitan Transportation District (TriMet, in Oregon)

### Midwest:

11. Champaign–Urbana Mass Transit District (C-UMTD, in Illinois)
12. Des Moines Metropolitan Transit Authority (DMMTA, in Iowa)
13. Madison Metro (in Wisconsin)
14. Suburban Mobility Authority for Regional Transportation (SMART, in Michigan)
15. Toledo Area Regional Transit Authority (TARTA, in Ohio)
16. Kansas City Area Transportation Authority (KCATA, in Missouri)
17. Metropolitan Council, Minneapolis (in Minnesota)
18. Pace, Suburban Bus Division of the Regional Transportation Authority (Pace, in Illinois)

### South:

19. Broward County, Florida, and municipalities within the county
20. Fort Worth Transportation Authority (in Texas)
21. Charlotte, North Carolina
22. Dallas Area Rapid Transit (DART, in Texas)

East:

23. Potomac and Rappahannock Transportation Commission (PRTC, in Virginia)
24. Merrimack Valley Regional Transit Authority (MVRTA, in Massachusetts)
25. Capital District Transportation Authority (CDTA, in New York)
26. Transportation District Commission of Hampton Roads (Hampton Roads Transit, or HRT, in Virginia)
27. Rhode Island Public Transportation Authority (RIPTA)
28. New Jersey Transit (NJ Transit)

## Key Issues and Trends

A number of key issues and trends emerged from the analysis of the preliminary case studies. The range of services offered by the agencies included in the case studies can be grouped into the following categories:

- Commuter,
- Route deviation,
- Demand responsive,
- Shuttles,
- Circulators, and
- Vanpools.

The commuter services are typically premium operations designed to attract a higher-income market through various service attributes, or reverse commute operations, which usually operate during nontraditional hours and are often funded by Job Access Reverse Commute (JARC) funds. Another trend is that premium commuter services require a higher farebox recovery ratio than standard fixed routes require to be considered successful. Using an employee from the job site as the driver, creating a “buspool” is one innovation observed at a case study site.

Success with route-deviation service, sometimes in concert with demand-responsive service, has been mixed. Several areas have abandoned or greatly reduced this type of service because of a variety of difficulties, including schedule adherence, customer complaints about advance scheduling, and lack of buy-in by operational personnel. Some agencies believed that mixing a fixed schedule with demand-responsive routing was a conflict in philosophies. However, other agencies appeared to successfully combine these concepts, especially when they were implemented as a substitute for existing service (as opposed to a stand-alone, new service). Some agencies considered route-deviated services successful if they exceeded the productivity rate of the local demand-responsive service, while others considered route

deviation successful if its productivity was comparable to the fixed-route average.

Among demand-responsive services, zone systems that capture internal trips or that link passengers to fixed routes have been successfully implemented. The size of the zone (including the number of attractions) and the availability of other services appeared to significantly affect productivity. The standards used to rate success varied by agency.

Some services named “shuttles” by their operating agency are similar to the demand-responsive services described above, while others were more fixed in nature, connecting neighborhoods or providing service to employment centers through connections at rail stations or transit hubs. Employer shuttles appeared to perform best with sustained employer participation.

Circulators exhibit many of the same characteristics as shuttles, with the possible exception that shuttles connect to a particular destination, while circulators typically connect to multiple activity points.

The information collected thus far on vanpools and ridesharing also varies by agency, with a key factor in agency participation being the ownership of the vehicles. In addition, one innovative service used by Pace is to keep vans at Metra stations to connect workers to their place of employment. This service also resembles the car sharing services, sometimes termed “station car” service, that have been employed in more urban areas of the country.

In addition to the observed services listed above, other issues are worth discussion:

- **Performance measurement.** One of the most thorough efforts to quantify service performance was completed by Pierce Transit. The performance criteria for one of Pierce Transit’s services are shown in Table 3-1. Other performance measurement systems of note are the MetCouncil’s (Twin Cities) thorough review of zones every 3 years and the MTDB’s (San Diego) combination of quantity- and quality-of-service goals. The quantitative criteria include passengers per revenue-mile, passengers per revenue-hour, and subsidy per passenger. The qualitative criteria can be grouped into three categories: transit-supportive land uses, regional transportation priorities, and quality of service. Denver RTD also uses performance measurement extensively for all types of services.
- **Funding.** Funding sources also appeared to influence both service availability and, to some degree, the productivity analysis. For example, a number of nontraditional services were funded by JARC or the federal Congestion Mitigation and Air Quality (CMAQ) program, while several agencies either had dedicated local funding taxes or were funded as a result of “opting out” of the transit district. In several instances, the lack of sustained funding from JARC or

**Table 3-1. Performance criteria for Pierce Transit.**

Age of Route	Passengers per Vehicle-Hour	Cost per Boarding Passenger*
New routes (less than 1 year old)	Satisfactory: >3.0 pass/hr	Satisfactory: <\$11.30/pass
	Unsatisfactory: <3.0 pass/hr	Unsatisfactory: >\$11.30/pass
Routes 1–2 years old	Satisfactory: >4.0 pass/hr	Satisfactory: <\$8.50/pass
	Unsatisfactory: <4.0 pass/hr	Unsatisfactory: >\$8.50/pass
Routes more than 2 years old	Satisfactory: >5.0 pass/hr	Satisfactory: <\$6.80/pass
	Unsatisfactory: <5.0 pass/hr	Unsatisfactory: >\$6.80/pass

\*All costs are in 2003 dollars. They should be indexed for inflation.

CMAQ determined if the service continued beyond the demonstration period. Services with dedicated funding were often held to different performance standards.

- **Interaction with communities.** Another apparent trend was the interaction between local communities and transit agencies. In several instances, programs were considered to be successful when transit dollars were added to community dollars for the provision of services designed by the community. In other instances, lack of continued community enthusiasm was cited as a factor in discontinuing or reducing service.

## Assessment of Practices

Interviews with representatives from the transit agencies from around the country revealed that many agencies use quantitative performance standards as they decide how to serve suburban areas that have uneven and relatively low demand. However, other factors heavily influence service design and provision decisions.

A weak economy in many areas of the country has resulted in lower-than-usual farebox and sales tax revenues, thereby limiting funds available to transit systems. When faced with limited resources, many agencies have chosen not to invest operating funds in areas of relatively low transit demand. Instead, they have strategically invested their limited resources in areas of higher density, where the highest ridership and revenues can be realized. Alternatively, some agencies provide service in lower-density suburban areas only when there is a funding source or partner that will pay for many of the service's expenses. For instance, in the Pace service district, no new suburban shuttle services are put in operation unless a major employer or a transportation management association (TMA) will subsidize the cost of operation. Hence, some of the services are being put into place not as a result of anticipated service performance, but as a result of dedicated funding.

A number of the agencies interviewed stated that they simply do not use service guidelines or standards to inform their decisions on where and how to serve lower-density suburban areas. For these agencies, service changes tend to be very incremental. To allocate their resources, the transit planners

use their local experience and their professional judgment of what kinds of development are likely to attract transit users. This professional judgment is often augmented by new service requests and policy influence, expressed as interest in service by transit board members or elected officials.

In the majority of cases reviewed, newer, more flexible forms of transit have been substituted for lower-productivity fixed-route service. Transit agencies are realizing that traditional fixed-route services are no longer viable in certain areas, or for certain bus routes, because of extremely low ridership. However, agencies still want to provide mobility options to expanded service areas. Route-deviated service, point-deviation service, or some form of demand-responsive “call-and-ride” service has a number of advantages under these circumstances:

- The transit agency does not leave former fixed-route passengers stranded without any service. This is important to the passengers, but also to the transit boards who see themselves as providers of mobility options.
- The sense of equity is maintained by providing broader coverage service throughout the area that supports the transit agency with taxes. Equity can be used as a rationale by transit agencies looking for community support at upcoming referenda for continued or expanded transit services.
- New, flexible service can be less expensive than traditional, fixed-route service since it is sometimes contracted out and provided with smaller vehicles. If complementary ADA paratransit service is not required when flexible, accessible transit is equally available to all passengers, potential savings can also be increased with flexible services.
- Smaller vehicles are often more compatible with the sensitivities of suburban neighborhoods, which are often sensitive to the noise and pollution generated by full-sized transit buses. Smaller vehicles are better able to negotiate crowded shopping centers, narrow residential streets, and the turns necessary to accommodate deviation requests.

Because these advantages are applicable regardless of whether agencies have separate standards or guidelines for flexible service, agencies often have no pressing need to develop such separate standards or guidelines. However, a

number of agencies measure the performance of new flexible services. Generally, this measurement is done because (a) the agency has very limited financial resources and might have to cut even these less expensive services (as has happened in Fort Worth, Texas, where eight different flexible routes were tried and terminated) or (b) the agency regards these services as any other service and, therefore, continuously reviews them to ensure that they are being used in the most appropriate locations (as in Tacoma, Washington).

The specific performance standards used to judge these newer services vary dramatically, although there is some agreement on the general expectations of flexible services. **The most commonly used quantitative performance measure is passengers per hour.** Virtually all transit agencies expect flexible services to perform better than standard paratransit service, but worse than traditional fixed-route service. **Most agencies are satisfied with service that carries between four and eight passengers per hour.** Some perform slightly worse than this, but are maintained as “lifeline” services, while a few others perform better than eight passengers per hour. The TriMet system in the Portland, Oregon, area requires its local suburban circulators to maintain a productivity level of 15 passengers per hour.

**Some agencies include the subsidy per passenger as another quantitative performance measure. Once again, the specific standard varies because of different cost structures around the country and different budget constraints, but the range of values is between \$4.50 and \$11.30.** Less often, transit agencies use the farebox recovery ratio as a primary determinant of whether the new transit service is viable. A threshold standard can vary from jurisdiction to jurisdiction, but many services establish a range of 20- to 25-percent farebox recovery as the threshold for continued service. Agencies often provide different “probationary periods,” during which they expect these new services to become established. The standard time frame ranges from 1 to 3 years, with 18 months as an average.

In addition to the quantitative measures that drive service decisions, there are often qualitative measures. As noted earlier, many flexible services are started as substitutes for less productive fixed-route service. In areas where flexible transit is introduced as a new service, the qualitative factors

influencing the decision to provide the service have included the following:

- Specific requests from major employment centers or communities, many of whom offer to help pay for the expense of providing the service.
- Strategic placement of service within communities to build support for transit referendums.
- Geographic or topographic characteristics that make the provision of regular fixed-route service impractical.
- A residential community’s proximity to premium transit service, such as rail or bus rapid transit (BRT) stations.
- Faster, more direct service. This is often accomplished by straightening trunk-line routes on major arterials and creating feeder routes to serve areas once served by the fixed route.
- Minimized traffic congestion and air pollution by providing a transit link between premium transit services and major employment centers.
- The provision of mobility services to residents of areas with relatively high unemployment to support their entry into the workforce.
- The provision of internal community trips with vehicles that can easily access shopping centers and other areas with relatively crowded and/or tight lane conditions.
- The use of smaller vehicles that are more acceptable to certain neighborhoods.
- A policy that all residents within a service area will have access to some form of public transit, even if it is limited service, as a “lifeline” for those with no other affordable mobility options.
- Regional policies that call for a relationship between different densities of land uses and levels of transit availability.
- The availability of funds from sources such as CMAQ, JARC, or state grant programs for experimental services.
- The provision of different services at times or on days that normally see less transit demand.

The specific quantitative and qualitative measures being used by the interviewed agencies are summarized in Tables 3-2 and 3-3, respectively. These tables represent only 20 of the 28 preliminary case studies because the information collected from 8 of the agencies was not applicable.

**Table 3-2. Quantitative factors decision matrix.**

Agency	City	State	Type of Service	No Standards	Min # Pax/Hr During Probation	Min # Pax/Hr After Probation	Probationary Period (Months)	Different Level of Service on Nights or Weekends	Maximum Subsidy/Pax (\$)	Minimum Ridership % on Route of System Average	Farebox Recovery Ratio (%)	Replacement Service for Underperforming Fixed Route	Funding Availability of Partner (for Service to Start)	Service in Areas with Minimum of 1,800 Persons/Mile <sup>2</sup>	Households/Acre
Eastern Contra Costa County Transit Authority	Antioch	CA			9	12	12				20		3		
Regional Transportation District	Denver	CO	Call-and-Ride		3		12					3			
South Metro Area Rapid Transit	Wilsonville	OR		3											
Metropolitan Transit Development Board	San Diego	CA	Access Routes		12		24		6.50						
Pierce Transit	Tacoma	WA	New routes		3		12		11.30				3	3	
			Routes 13 – 24 months		4		12		8.50				3	3	
			Routes 25 months +		5				6.80				3	3	
Champaign-Urbana Mass Transit District	Champaign-Urbana	IL	Dial-A-Ride		3										3

Kansas City Area Transportation Authority	Kansas City	MO	Demand Responsive	3											
Suburban Mobility Authority for Regional Transportation	Detroit	MI	Flex Routes	3											
Des Moines Metropolitan Transit Authority	Des Moines	IO	Dial-A-Ride (evenings only)		5			3				3			
Toledo Area Regional Transit Authority	Toledo	OH	Dial-A-Ride		3										
Metropolitan Council	Minneapolis	MN	Suburban		5				4.50						3 - 5
			Dial-A-Ride		2			4.50							<3
Potomac and Rappahannock Transportation Commission	Manassas	VA	Route Deviation (evenings)		4										
Capital District Transportation Authority	Albany	NY	Flex Routes	3									3		
Pace Transit	Chicago	IL					12		5.00	50	20		3		
TriMet	Portland	OR	Circulator		15		24 - 36								
Dallas Area Rapid Transit	Dallas	TX	Curb-to-Curb	3	6				4.30			3			
Rhode Island Public Transportation Authority	Rhode Island	RI		3											
Broward County	Ft. Lauderdale	FL	Circulator		5										
Ft. Worth Transportation Authority	Ft. Worth	TX		3								> paratransit services			
New Jersey Transit	Newark	NJ					24					20			

**Table 3-3. Qualitative factors decision matrix.**

Agency	City	State	Type of Service	Substitute Service for Unproductive Fixed Routes	Reviews Land-Use Development Plans/Proposals	Geography & Topography Considered	Ensuring Communitywide Mobility Opportunities	Community Feedback Determined Need	Developing Community Support for Transit	Employment Opportunity/ Unemployment/ Population Motivated	Avoids ADA Requirement/ Expenses	Lifetime Service	Proximity to Rail Station	Funding Availability of Partner (for Service to Start)	Feeder Service to Regular or Premium Transit Network	Environmentally Motivated	Desire to Streamline Regional Network	Desire for Internal Community Trips	Protest Against Large Buses in Neighborhood	Visible Use of Taxpayer \$	
Eastern Contra Costa County Transit Authority	Antioch	CA			✓																
Regional Transportation District	Denver	CO	Call-and-Ride						✓										✓	✓	
South Metro Area Rapid Transit	Wilsonville	OR																			
Metropolitan Transit Development Board	San Diego	CA	Access Routes																		
Pierce Transit	Tacoma	WA	New routes			✓															
			Routes 13 – 24 months			✓															
			Route 25 months +			✓															
Champaign-Urbana Mass Transit District	Champaign-Urbana	IL	Dial-A-Ride			✓	✓														
Kansas City Area Transportation Authority	Kansas City	MO	Demand Responsive	✓						✓											
Suburban Mobility Authority for Regional Transportation	Detroit	MI	Flex Routes						✓	✓											
Des Moines Metropolitan Transit Authority	Des Moines	IO	Dial-A-Ride (evenings only)	✓							✓	✓									
Toledo Area Regional Transit Authority	Toledo	OH	Dial-A-Ride				✓		✓												
Metropolitan Council	Minneapolis	MN	Suburban				✓				✓	✓									
			Dial-A-Ride			✓															
Potomac and Rappahannock Transportation Commission	Manassas	VA	Route Deviation (evenings)								✓										
Capital District Transportation Authority	Albany	NY	Flex Routes					✓		✓											
Pace Transit	Chicago	IL								✓				✓							
TriMet	Portland	OR	Circulator		✓										✓			✓			
Dallas Area Rapid Transit	Dallas	TX	Curb-to-Curb						✓				✓		✓				✓	✓	
Rhode Island Public Transportation Authority	Rhode Island	RI					✓			✓		✓									
Broward County	Ft. Lauderdale	FL	Circulator												✓		✓				
Ft. Worth Transportation Authority	Ft. Worth	TX		✓																	
New Jersey Transit	Newark	NJ								✓		✓			✓	✓					

## CHAPTER 4

# Detailed Case Study Findings

After analyzing general data from the preliminary case studies, the research team focused on a more in-depth analysis of a select group of transit agencies. In choosing the agencies for this select group, the research team sought to balance the distribution of geography and agency size. Because a key goal of the research was to illustrate the nexus between land use and suburban transit services, sites with more extensive data on land use, demographics, and operations were given priority. The research team chose sites with a range of suburban transit services, from both large urban and small rural areas of the country, both with and without specific policies guiding service implementation:

- King County Metro (Seattle, Washington),
- Tri-Met (Portland, Oregon),
- South Metro Area Rapid Transit (Wilsonville, Oregon),
- Regional Transportation District (Denver, Colorado),
- Metropolitan Council (Minneapolis area, Minnesota),
- Suburban Mobility Authority for Regional Transportation (suburban Detroit, Michigan),
- Broward County Transit (Broward County, Florida), and
- Capital District Transportation Authority (Albany, New York).

As indicated in Tables 4-1 through 4-3, the recommended sites vary in size, provide broad geographical coverage, and offer a wide range of service alternatives.

### Case Study Research Methodology

The research team developed a detailed information request form, as summarized below:

- **Transit Characteristics**
  - Service characteristics
    - % of households or jobs within service area, response time, number of vehicles in peak service, intermodal hubs, technology (signal preemption/next bus)
  - Vehicle characteristics
    - Vehicle type, capacity (seats/wheelchair positions), technology (annunciators, automatic vehicle location [AVL], smartcards)
- **Route Characteristics**
  - Headway (peak/off peak); average speed; trips per weekday, Saturday, and Sunday; route length (mi/hr); service span (weekdays/Saturday/Sunday)
- **Performance**
  - Annual passengers, revenue-hours, revenue-miles, vehicle-hours, vehicle-miles, cost/passenger, cost/hour, cost/mile, subsidy/passenger, farebox recovery ratio
- **Funding Sources**
- **Transit Policy**
  - Board role and involvement, decision-making process, guidelines, performance measurement system (describe), organizational model, other unique characteristics
- **Land Use and Travel Patterns**
  - Key attractions
    - Large employers, schools, shopping centers, medical centers, museums, arenas, hotels
  - Land use by parcel
    - Residential (dwelling units by parcel or block), commercial (square footage of leasable space)
  - Travel behavior
    - Origin-destination travel patterns, trip purposes, trip frequency
- **Demographics**
  - Household income, car ownership, age composition, unemployment rate, non-English-speaking populations, average household size
- **Street Network Characteristics**
  - Street width, number of lanes, speed limit, signal spacing, average daily traffic, volume/capacity ratio, level of service (LOS), connectivity, distance between bus stops
- **Transit Priority Features**
  - Traffic signal priority, queue jump lanes, exclusive lanes



**Table 4-1. Detailed case study sites by agency size.**

<b>Small</b> (Fewer than 100 buses)	<b>Medium</b> (100 – 600 buses)	<b>Large</b> (More than 600 buses)
South Metro Area Rapid Transit, SMART (OR)	Capital District Transportation Authority, CDTA (NY)	Denver Regional Transportation District, Denver RTD (CO)
	Broward County Transit, BCT (FL)	King County Metro, Metro (WA)
	Suburban Mobility Authority for Regional Transportation, SMART (MI)	Metropolitan Council, MetCouncil (MN)
		Tri-County Metropolitan Transportation District, TriMet (OR)

**Table 4-2. Detailed case study sites by agency location.**

<b>East</b>	<b>South</b>	<b>Midwest</b>	<b>West</b>
Capital District Transportation Authority, CDTA (NY)	Broward County Transit, BCT (FL)	Suburban Mobility Authority for Regional Transportation, SMART (MI)	South Metro Area Rapid Transit, SMART (OR)
		Metropolitan Council, MetCouncil (MN)	Tri-County Metropolitan Transportation District, TriMet (OR)
			King County Metro, Metro (WA)
			Denver Regional Transportation District, Denver RTD (CO)

**Table 4-3. Detailed case study sites by transit services offered.**

<b>Transit Services</b>	Broward County Transit, BCT (FL)	Capital District Transportation Authority, CDTA (NY)	Denver Regional Transportation District, Denver RTD (CO)	Metropolitan Council, MetCouncil (MN)	King County Metro, Metro (WA)	South Metro Area Rapid Transit, SMART (OR)	Suburban Mobility Authority for Regional Transportation, SMART (MI)	Tri-County Metropolitan Transportation District, TriMet (OR)
<b>Fixed Route</b> - Circulator/Shuttle	✓	✓	✓	✓	✓	✓	✓	✓
<b>Demand Responsive</b>	✓		✓	✓	✓	✓	✓	✓
<b>Flexible</b> -Route Deviation -Point Deviation	✓	✓			✓ ✓		✓ ✓	✓
<b>Commuter</b> -Bus -Vanpool			✓ ✓			✓		✓

- **Parking Cost or Scarcity**

- Average cost of parking, metered parking, structures

Much of the transit service data were available from the transit agencies. To obtain data on land use, the research team typically had to work with multiple agencies at city, county, and regional levels. In general, there was a considerable lack of consistency among the data available at the various detailed case study sites. However, the need remained to develop analyses that could consider the range of planning and land-use information available to the broader transit community, such that guidance could be developed even with a range of specificity of data available.

## Overview of Results

Land-use data are becoming more readily available in many areas, but the lead agency for maintaining the data and the types of data maintained can vary from one locale to another. Further, although some transit operators are very familiar with these data, others do not use the land-use data, especially in the specific ways developed in the research plan. As a result, no single method can be prescribed to access similar land-use data across the country.

However, the general methodology employing the “four D’s” can provide comparative information at the local level that will assist in understanding the comparative potential of various land-use factors to better support suburban transit options. Further, the terminology and analysis of peaks, ridges, points, and plains accurately describe the best service delivery options for a given disaggregated land-use area.

The majority of the effort being expended by transit agencies, as reflected by the types of services included in the case studies, involves trying to serve lower-density areas with multiple land uses (residential, schools, commercial, and health-care). The range of solutions, from fixed route to route deviation, has some interesting land-use correlations:

- Most services are operating in areas of less than 20,000 trip ends per square mile. This metric appears to be relatively new, and perhaps it will be a new threshold for transit agencies to consider in planning activities.

- Trip density in a given area is not a consistent factor in attracting more riders per hour.
- Land use with mixed development appears to perform better than land use of one type (e.g., residential or commercial).

Clearly, in many instances, land use dictated the types of services provided. For example, on the job access routes in suburban Detroit serving the industrial areas, circulators with direct connections to the worksites were the best fit.

However, sometimes land use did not dictate the type of services provided. For example, in Minneapolis, in choosing between route deviation and point deviation, the most important factor was the high number of attractors that needed to be served. Minneapolis thus chose the strict scheduling of route deviation instead of the flexibility of point deviation because route deviation could serve more attractors than point deviation could serve. The productivity of route-deviation service was significantly higher than that of point-deviation service.

As will be discussed further in the detailed case study analysis, the preliminary case study analysis demonstrates several key findings. First, there is a wide range of perspectives regarding the role of suburban services, with evidence that coverage is more important than productivity. This perspective on suburban services differs from the general perspective on fixed-route services. Productivity, in general, has been the main factor for evaluating fixed-route services. Thus, there sometimes are competing perspectives when evaluating suburban services. Second, recognizing the benefits of some of the coverage-oriented programs has resulted in better working relationships between transit agencies and communities, including passage of funding resources legislation, as evidenced by the SMART service in suburban Detroit. Conversely, in other areas locales have opted out of the transit district to make their own policy decisions and even provide funding for those services, like has happened for the Met Council area. Obviously, the ability to fund services that have much lower productivity than many fixed route systems is critical to maintaining sustainability, whether this ability is based on policies to provide area coverage, local participation in funding the transit agency, or directly funding the services.

## CHAPTER 5

# Results and Performance Evaluation

This chapter synthesizes the findings of the preliminary and detailed case studies to identify applicable traits that transit agencies can consider in establishing suburban transit services. To show how the applicable traits may relate to one another, the chapter presents several analyses. However, because the findings of this study were insufficient to establish concrete guidelines for all transit agencies, each of the analyses in the chapter uses only a few case studies. Therefore, the findings of the analyses in this chapter cannot be extended to all transit agencies. Nonetheless, the traits identified in this chapter can help transit agencies think about the issues involved in suburban transit services.

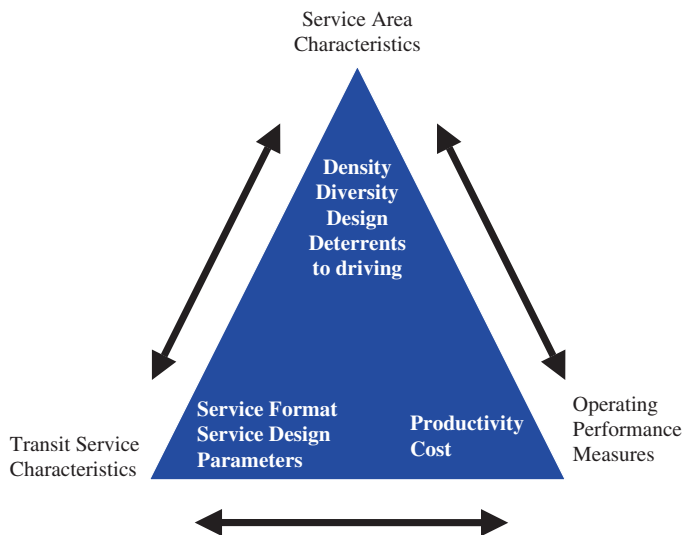
### Analysis of Land Use versus Transit Service and Operating Performance

An analysis was performed on routes in Albany, Detroit, Minneapolis, and Portland to determine the relationship of land use (i.e., service area characteristics) to transit service characteristics and operating performance measures. Figure 5-1 shows this research objective, and Figure 5-2 shows the types of suburban transit services available. Figure 5-3 shows the routes that were analyzed for this portion of the report. Figures 5-4, 5-5, and 5-6 show the “spatial adaptation” (i.e., flexibility of location), “temporal adaptation” (i.e., flexibility of time), and demand level, respectively, of all the routes.

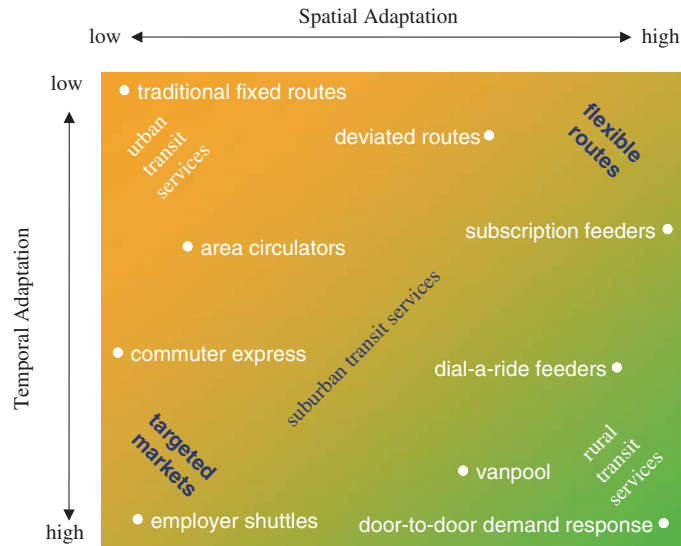
Although no clearly defined characteristics were isolated, a series of findings were made:

- Most services are in areas with fewer than 20,000 trip ends per square mile (see Figure 5-7).
- The best performing services (with performance measured in passengers per hour) are among the least flexible (see Figure 5-8).

- Ridership is not a simple function of density. Local policy decisions often appear to accept lower productivity (as measured in passengers per hour) as a trade-off for increased coverage (see Figure 5-9).
- The best performing routes (with performance measured in passengers per hour) are among those serving the most balanced mix of land uses (see Figure 5-10).
- Services that target specific groups, such as seniors and students, seem to be among the most productive (with productivity measured in passengers per hour and weekday revenue-hours) (see Figure 5-11).



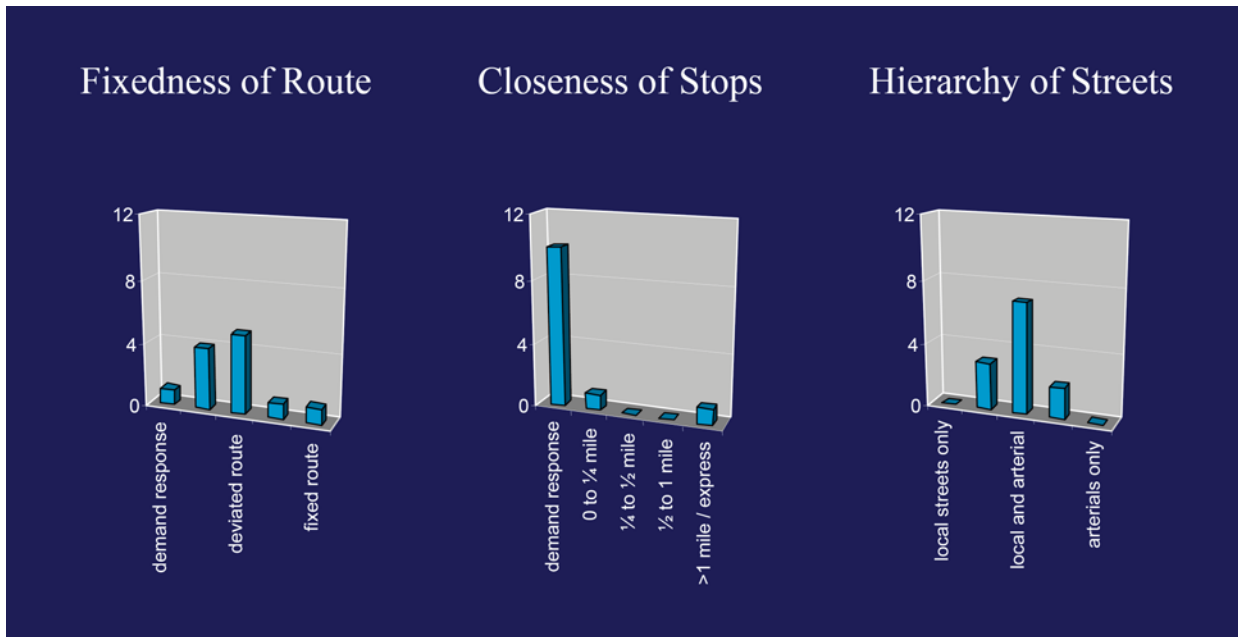
**Figure 5-1. Research objective: To determine the relationship of land use (i.e., service area characteristics) to transit service characteristics and operating performance measures.**



**Figure 5-2. Spatial and temporal flexibility, or “adaptation,” of different types of suburban transit services.**

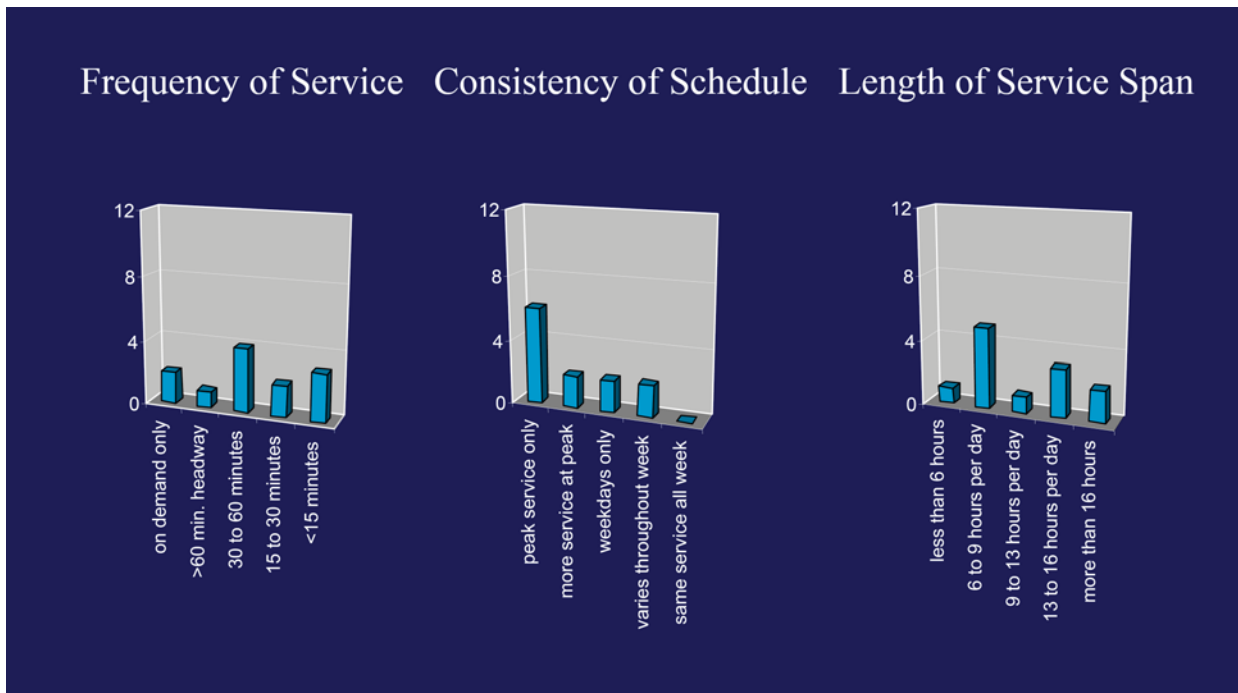


**Figure 5-3. Case study routes that were analyzed for this portion of the report.**



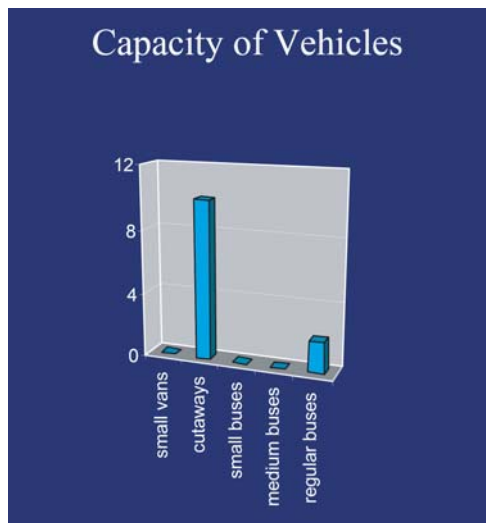
Note: Numbers on the y-axis represent the number of routes analyzed for this portion of the report. Bars without x-axis labels represent services that incorporate characteristics of both the service to the right and the service to the left of the bar.

**Figure 5-4. Spatial adaptation of the routes analyzed for this portion of the report.**



Note: Numbers on the y-axis represent the number of routes analyzed for this portion of the report.

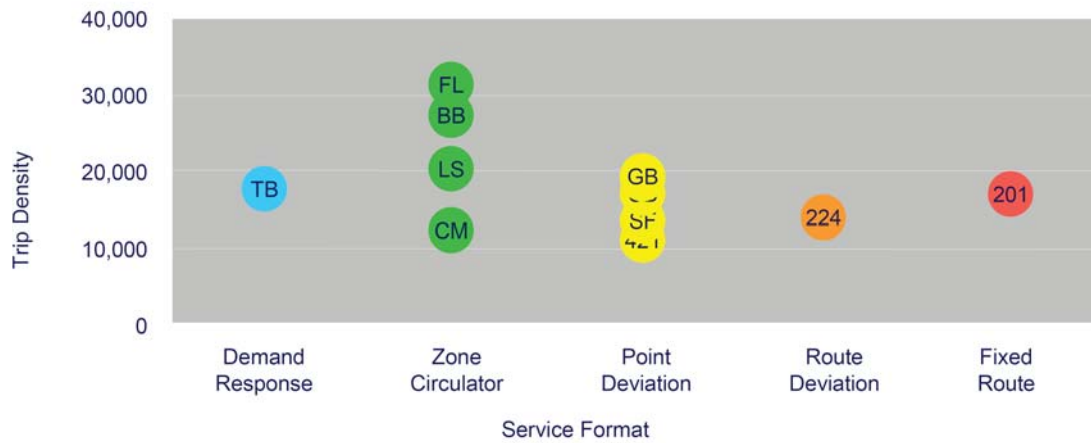
**Figure 5-5. Temporal adaptation of the routes analyzed for this portion of the report.**



Note: Numbers on the y-axis represent the number of routes analyzed for this portion of the report.

**Figure 5-6. Demand level of the routes analyzed for this portion of the report.**

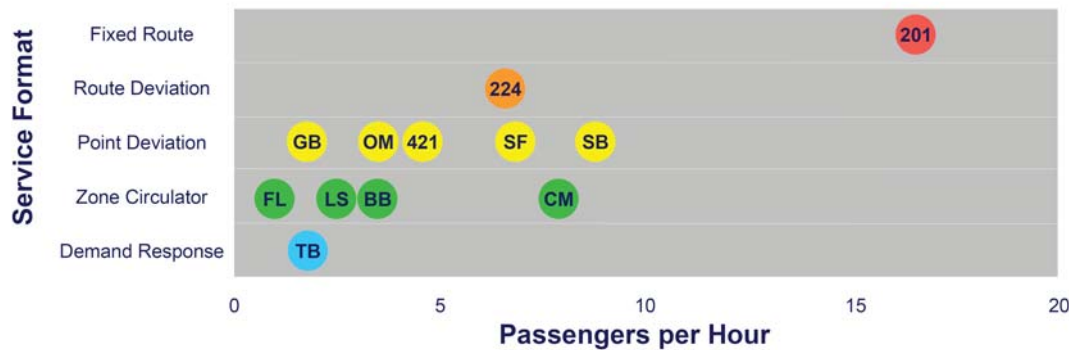
Finding: Most services are in areas with fewer than 20,000 trip ends per square mile.



Note: See Figure 5-3 for a “key” to the colors and abbreviations listed here.

**Figure 5-7. Density versus transit service.**

Finding: The best performing services are among the least flexible (with performance measured in passengers per hour).



Note: See Figure 5-3 for a “key” to the colors and abbreviations listed here.

**Figure 5-8. Route flexibility or time flexibility versus productivity.**

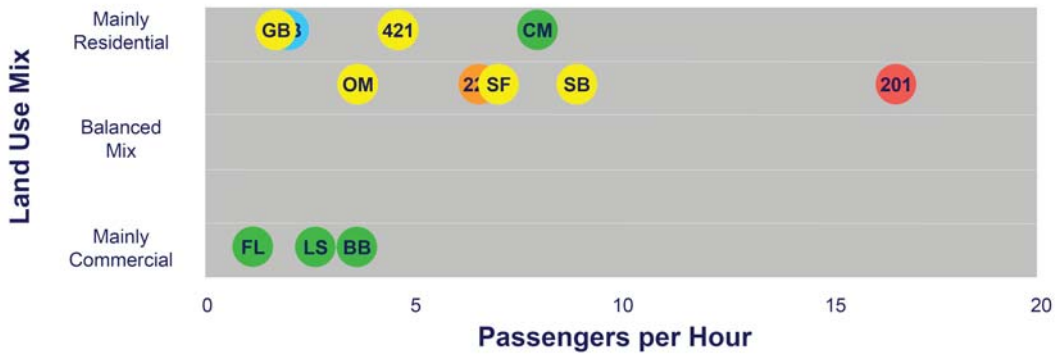
Finding: Ridership is not a simple function of density. Local policy decisions often appear to accept lower productivity as a trade-off for increased coverage (with productivity measured in passengers per hour).



Note: See Figure 5-3 for a “key” to the colors and abbreviations listed here.

Figure 5-9. Trip density versus productivity.

Finding: The best performing routes (with performance measured in passengers per hour) are among those serving the most balanced mix of land uses.



Note: See Figure 5-3 for a “key” to the colors and abbreviations listed here.

Figure 5-10. Land-use mix versus productivity.

Finding: Services that target specific groups seem to be among the most productive (with productivity measured in passengers per hour and weekday revenue-hours).



Note: See Figure 5-3 for a “key” to the colors and abbreviations listed here.

Figure 5-11. Service level versus productivity.

## Analysis of Performance Measurement versus Demographics, Service Delivery, and Pedestrian Network

Following the land-use analysis, a more traditional transit performance measurement analysis was performed, with demographics, service delivery, and pedestrian network evaluated for the case study routes.

The routes were characterized in two ways: (1) by the trip type served (the home end of a trip versus the work end of a trip) and (2) by the type of service (local fixed route, flexible route, and commuter). Each route's service area was defined as follows:

- **Fixed route**—all areas within one-quarter mile air distance of any branch of the route.
- **Dial-a-ride**—the dial-a-ride service area.
- **Deviated route**—the combination of the route deviation area and all other areas within one-quarter mile of the fixed-route portion of the route.
- **Commuter**—the areas within one-quarter mile of the local service portion of the route, where customers would mainly be boarding in the morning. The destination ends of the routes (transit centers) were not included.

Table 5-1 shows the routes that were evaluated and their characteristics.

### Demographics

The smallest geographic unit available—either Census block group or Census traffic analysis zone (TAZ)—was used to estimate the viability of transit service in a given area:

- **Population density**—the number of persons per square mile within the service area.
- **Job density**—the number of employees per square mile within the service area.
- **Percentage of population 0-17 years old.**
- **Percentage of population 65 or more years old.**
- **Percentage of households with no vehicles available.**
- **Percentage of employees with no vehicles available at home.**
- **Average median income**—the median income was known for each census block or TAZ; a weighted average of these median incomes was determined for the service area as a whole.

### Service Delivery

The following service delivery variables were evaluated:

- **Adult peak fare**—the lowest (e.g., one-zone) adult fare during peak periods.

- **Service area**—calculated in square miles, using GIS software.
- **Weekday TLOS indicator**—the Florida Transit Level of Service (TLOS) indicator<sup>1</sup> measures a combination of *service frequency* and *span*. In this application, it measures the percentage of a weekday that locations within the service area have access to transit.

### Pedestrian Network

The following factors relating to street network connectivity were evaluated:

- **Network connectivity factor**—the number of links (i.e., street segments between intersections) within the service area, divided by the number of nodes (i.e., intersections).
- **Average minimum circularity ratio**—the minimum circularity ratio was determined for all blocks falling within a given one-half mile grid square, and the average of the minimum circularity ratios was calculated based on all grid squares intersecting a route's service area.
- **Average block size factor**—the ratio of a block's area (in square miles) to one-fiftieth square mile. An average value of 1.0 or less suggests a relatively dense, walkable street network. The average block size factor was calculated based on all blocks intersecting a route's service area.

### Findings

Figures 5-12 through 5-15 highlight the most promising relationships between the evaluated factors and route productivity.

The six flexible-route services showed a strong correlation between population density and productivity (see Figure 5-12), which contrasts with the more limited correlation between trip density and productivity shown previously in Figure 5-9. The remaining local fixed-route services showed a fairly weak correlation between population density and productivity.

There was some correlation between the productivity of the employer-oriented services and the percentage of employees who had no vehicle at home (see Figure 5-13).

There was some correlation between productivity and the amount of service provided, as measured by the Florida TLOS indicator, which includes both the span and frequency of service (see Figure 5-14).

There was relatively good correlation between productivity and the service area size, with the result that the larger the service area, the less productive the service (see Figure 5-15).

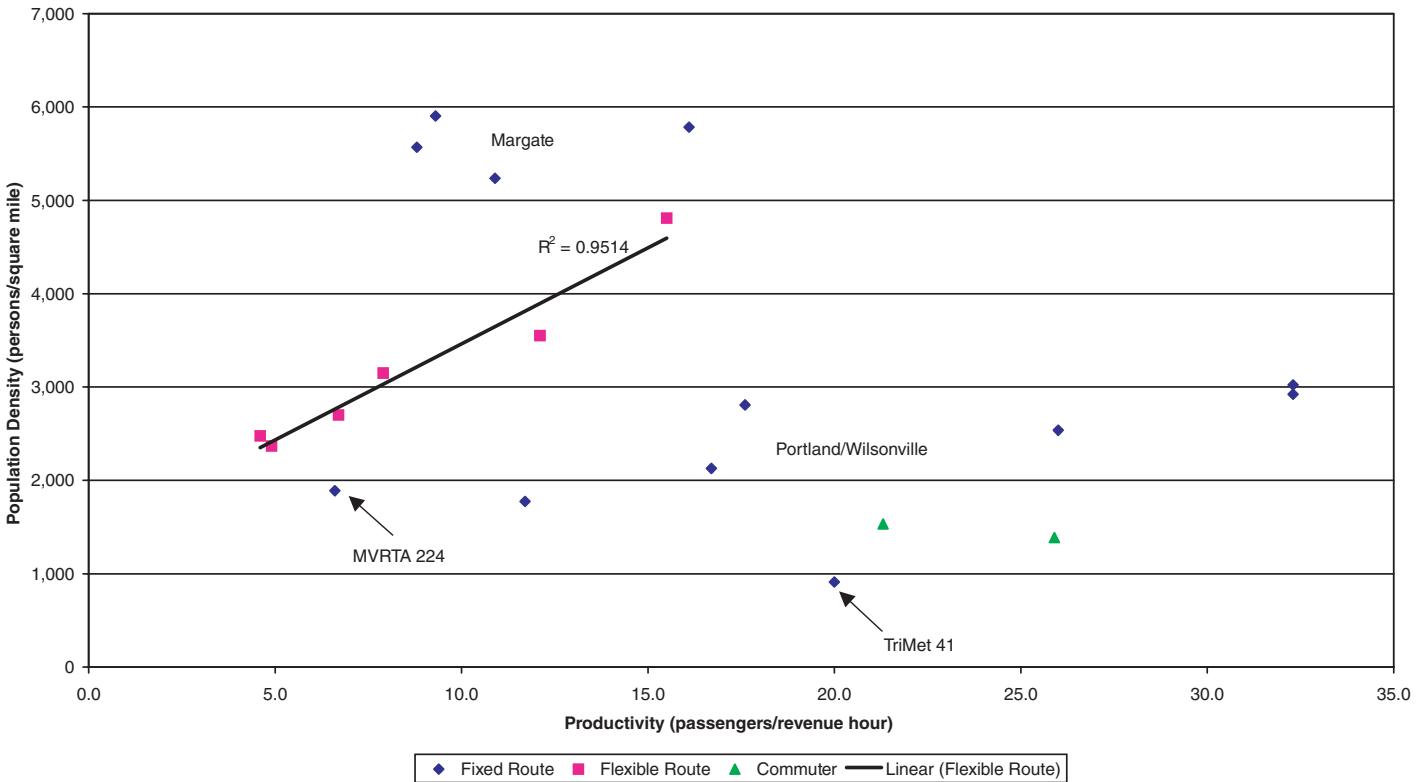
Factors that showed no apparent correlation with route productivity included fares, percentage of population under 18, and walkability.

<sup>1</sup> Ryus, Paul, Jon Ausman, Daniel Teaf, Marc Cooper, and Mark Knoblauch, "Development of Florida's Transit Level of Service Indicator," *Transportation Research Record 1731*, Transportation Research Board, National Research Council, Washington, DC (2000).



**Table 5-1. Routes evaluated for the effects of demographics, service delivery, and pedestrian network on performance measurement.**

Route	Agency	Type	Trip End
Margate A	BCT	Fixed Route	Home
Margate B	BCT	Fixed Route	Home
Margate C	BCT	Fixed Route	Home
Margate D	BCT	Fixed Route	Home
Cedar Mill Shuttle	TriMet	Dial-a-Ride	Home
155 Sunnyside	TriMet	Fixed Route	Home
156 Mather Rd	TriMet	Fixed Route	Home
157 Happy Valley	TriMet	Fixed Route	Home
204 Wilsonville Rd	SMART (Wilsonville)	Fixed Route	Home
903 Federal Way	King County Metro	Deviated Route	Home
914 Kent	King County Metro	Deviated Route	Home
927 Issaquah-Sammamish	King County Metro	Deviated Route	Home
421 Burnsville-Savage	MVRTA	Deviated Route	Home
152 Milwaukie	TriMet	Fixed Route	Work
41 Hawthorn Farm	TriMet	Fixed Route	Work
50 Cornell Oaks	TriMet	Fixed Route	Work
201 Barbur	SMART (Wilsonville)	Commuter	Work
1X Salem	SMART (Wilsonville)	Commuter	Work
291 Redmond	King County Metro	Deviated Route	Work
224 Shoreview-Roseville	MVRTA	Fixed Route	Work



**Figure 5-12. Population density versus productivity.**

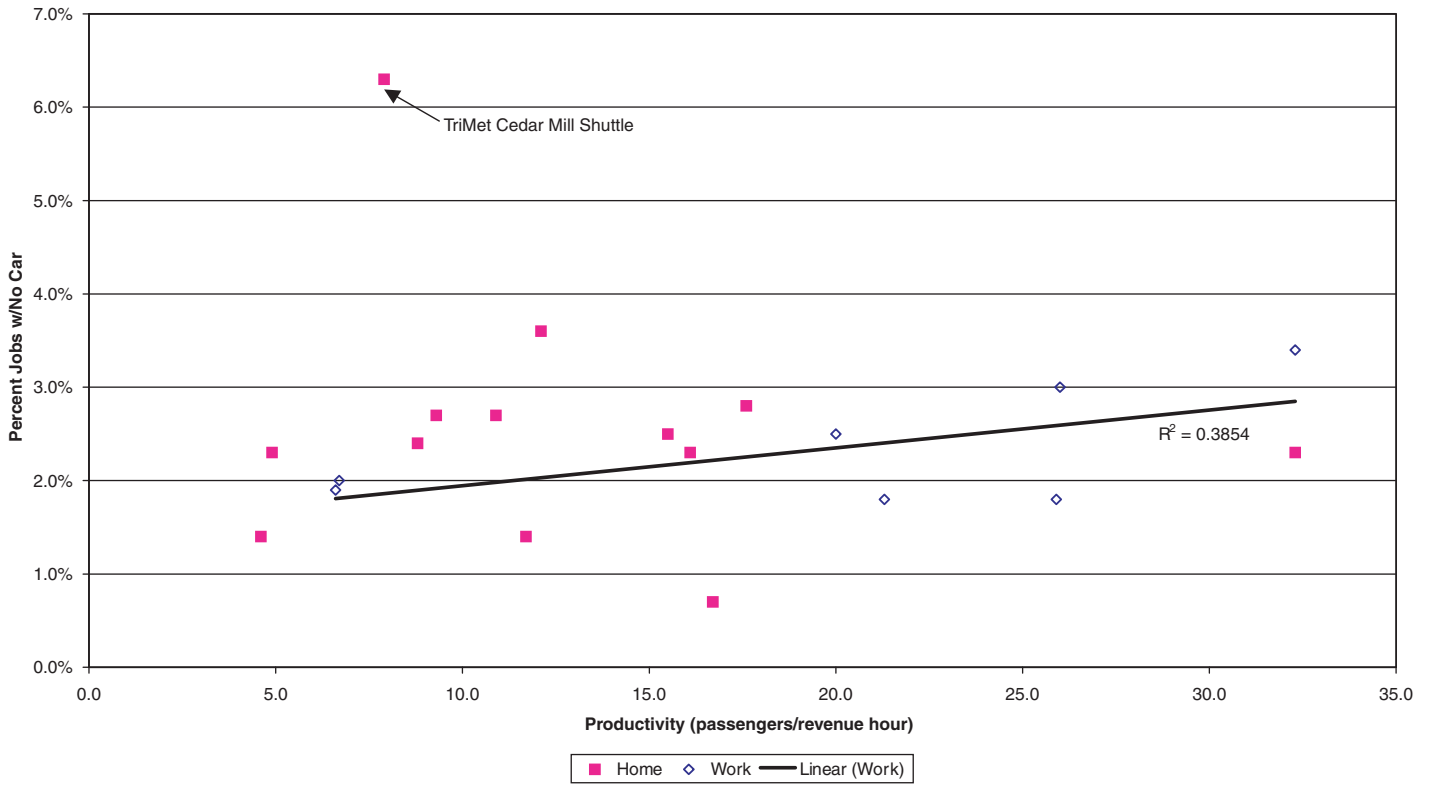


Figure 5-13. Productivity of employer-oriented services versus the percentage of employees who had no car at home.

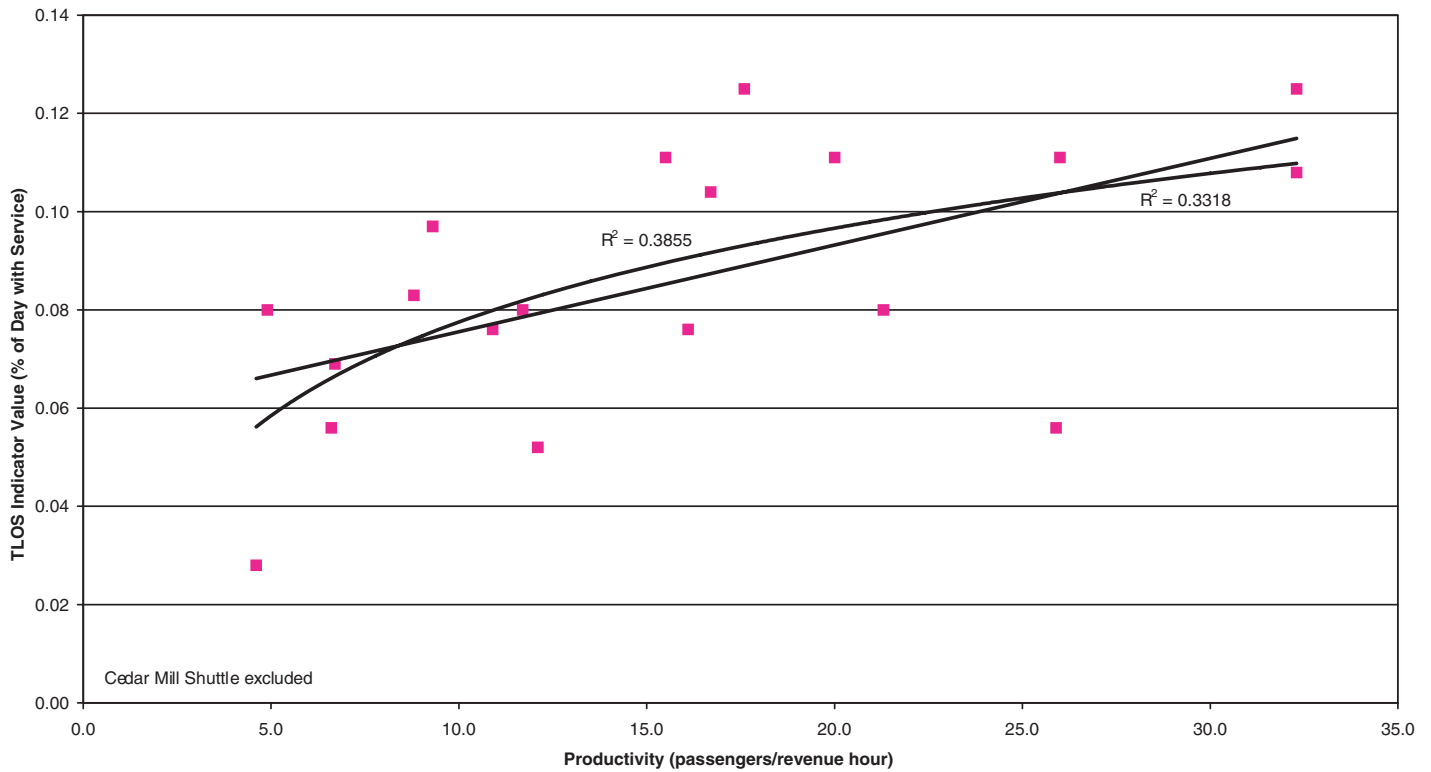
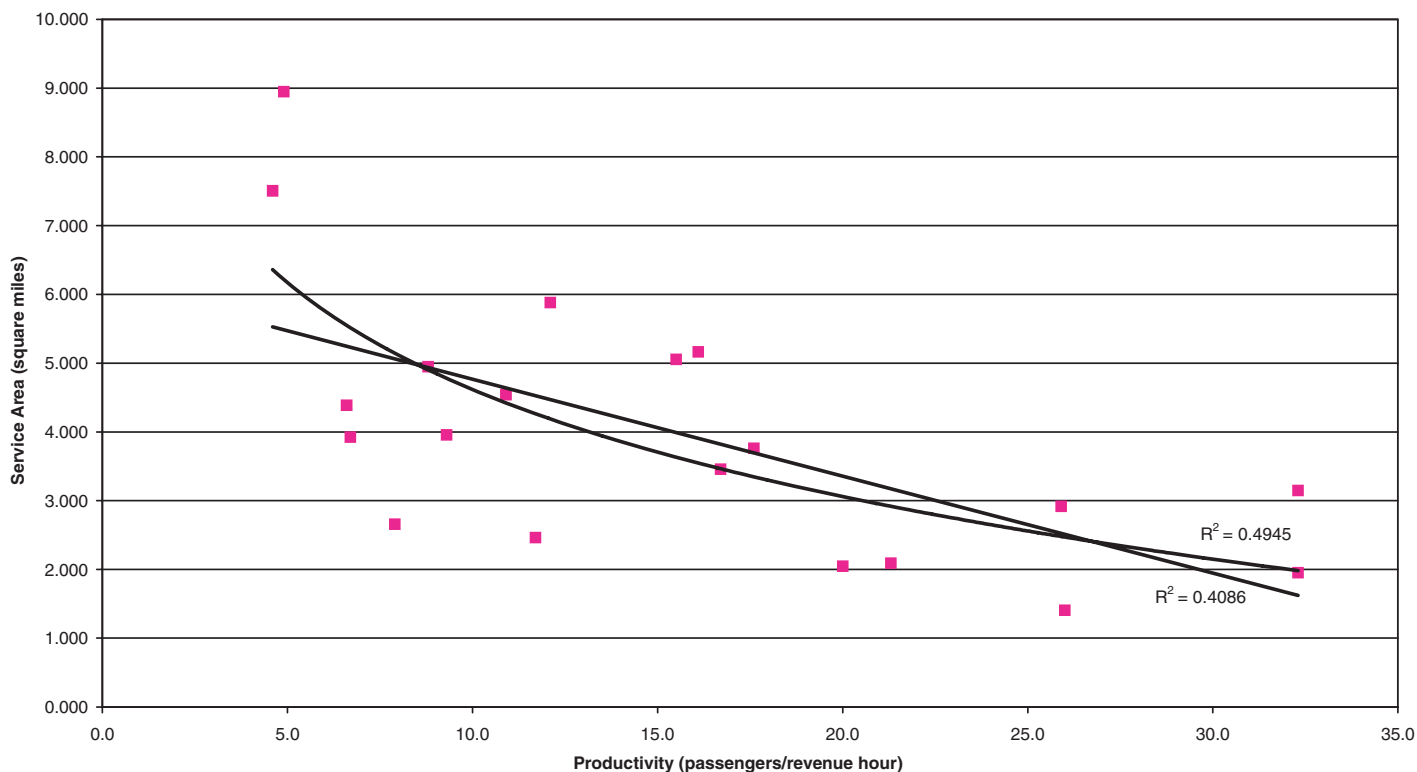


Figure 5-14. Florida Transit Level of Service (TLOS) indicator versus productivity.



**Figure 5-15. Service area size versus productivity.**

The demand-responsive services, when looked at as a group, tended to show better correlation for several factors than the correlation shown for these factors by other services. Two possible explanations for this are that (1) the demand-responsive services tended to serve larger areas than the fixed-route and commuter services and (2) none of the demand-responsive services overlapped with each other.

To sum up, many of the fixed-route services that were studied had service areas that significantly overlapped with other fixed-route services. Because the overlapping services covered areas with relatively similar population densities, any differences in productivity would be the result of other factors. In contrast, all of the demand-responsive services that were studied served unique areas that were not part of the service areas of other studied routes. Thus, the variety of services that were included in this analysis from various parts of the country did not provide many significant findings, with the following exception: Population density, not trip density, proved to have a good correlation to productivity, especially for demand-responsive services.

### Relating the Land-Use Analysis to the Transit Performance Measurement Analysis

Matrixes can be developed to help transit agencies determine the most appropriate form of transit and to measure

performance over time. Table 5-2 provides an example matrix comparing performance measures with service types for the services discussed thus far in this chapter. The left group of performance measures represents traditional measures that most transit agencies already use. The right group of performance measures represents nontraditional measures suggested in this report based on land use (i.e., service area characteristics) and transit service characteristics. The center group of performance measures represents the application of both groups of measures to the routes discussed thus far in this chapter.

The services have been structured to isolate performance measurement ranges that transit planners can use in establishing their own services and measures for evaluation.

### Activity Surface Example

As indicated in a previous section, where sufficient demographic and land-use data are available in GIS format, an activity surface can be created to depict the land-use and travel patterns. Figures 5-16 through 5-18 and Table 5-3 show an example of how this activity surface can be tied to suburban transit service planning. The agency featured in this example is MetCouncil in Minnesota.

Route 224 serves an area with more density and destinations than Route 421. This is depicted in Figure 5-16 by the

**Table 5-2. Service types versus performance measures.**

Service Types	Performance Measures													
	Traditional measures*			Application of traditional and nontraditional measures to case study routes							Nontraditional measures suggested in this report*			
	Annual Ridership	Annual Revenue-Hours	Passengers per Hour	Annual Ridership	Annual Revenue-Hours	Passengers per Hour	Weekday TLOS Indicator	Service Area	Network Connectivity Index	Productivity	Weekday TLOS Indicator	Service Area	Network Connectivity Index	Productivity
<b>Fixed Route</b>	11,599	1,770	6.6	11,599	1,770	6.6	0.056	4.387	1.57	6.6	0.056–0.125	1.408–5.164	1.410–1.680	6.600–32.300
<b>Demand Responsive</b>	13,970	1,778	7.9	13,970	1,778	7.9	0.292	2.660	1.37	7.9	0.292	2.66	1.37	7.9
<b>Flexible</b>	4,064–29,464	953–16,929	1.0–8.8	4,352	953	4.6	0.028	7.506	1.59	4.6	0.028–0.111	3.924–8.947	1.47–1.59	4.6–15.5
<b>Commuter</b>	83,800	5,080	16.5	83,800	5,080	16.5	0.080	2.091	1.84	21.3	0.056–0.080	2.091–2.919	1.77–1.84	21.3–25.9

Weekday TLOS Indicator = % of day service provided to bus stops along route, with each fixed-route-only bus providing 10 minutes worth of transit access.

Service Area = route service area (square miles).

Network Connectivity Index = (# of intersections/# of links) in area served by route (<1.30 = cul-de-sac pattern, 1.30-1.55 = hybrid pattern, >1.55 = grid pattern).

Productivity = boardings per revenue-hour.

\*Values in these columns represent typical ranges or averages that transit agencies may find for their services.

**Table 5-3. Operational performance of MetCouncil Routes 224 and 421.**

Performance Measure	Route 224	Route 421
Annual passengers	11,599	4,352
Revenue-hours	1,770	953
Passengers per hour	6.6	4.6
Cost per passenger	\$6.48	\$18.73
Cost per hour	\$42.45	\$85.54

Source: MetCouncil Route Profiles



**Figure 5-16. MetCouncil (Minnesota) activity surface.**

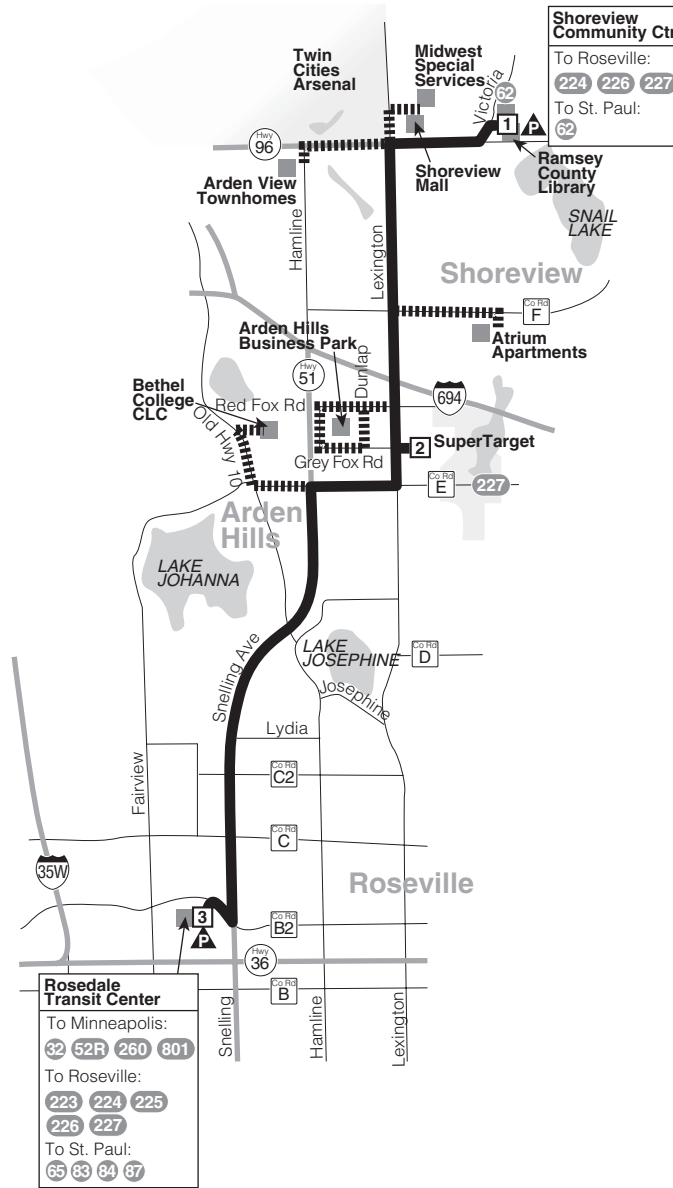


Figure 5-17. Route 224 map.

darker shading and numerous ridges. Thus, the planning solution for Route 224 was to add a few route deviations, but maintain a general fixed-route orientation (see Figure 5-17). Conversely, Route 421 was designed to serve a broader area with flexible-route service, which has more demand-responsive characteristics than fixed-route characteristics (see Figure 5-18). The differences from serving diverse markets and densities are reflected in the operational information, which shows higher ridership, more service hours, and lower costs for Route 224 than for Route 421 (see Table 5-3). Thus, the efficiency and effectiveness, measured in passengers per hour and cost per passenger, was better for the route-deviation service (Route 224),

although more service area coverage was provided under the flexible-route service (Route 421).

Note: Although MetCouncil and some other areas that were examined in this study had the necessary demographic and land-use information available to display in GIS format, most areas either did not have data readily available in this format or had the data housed in multiple agencies, which resulted in numerous difficulties in collection, display, and comparison with transit data. There are indications that more areas are looking to connect the land-use and transit data in GIS format, which in the long term will assist in developing more land-use and transit relationships for consideration in suburban service planning.

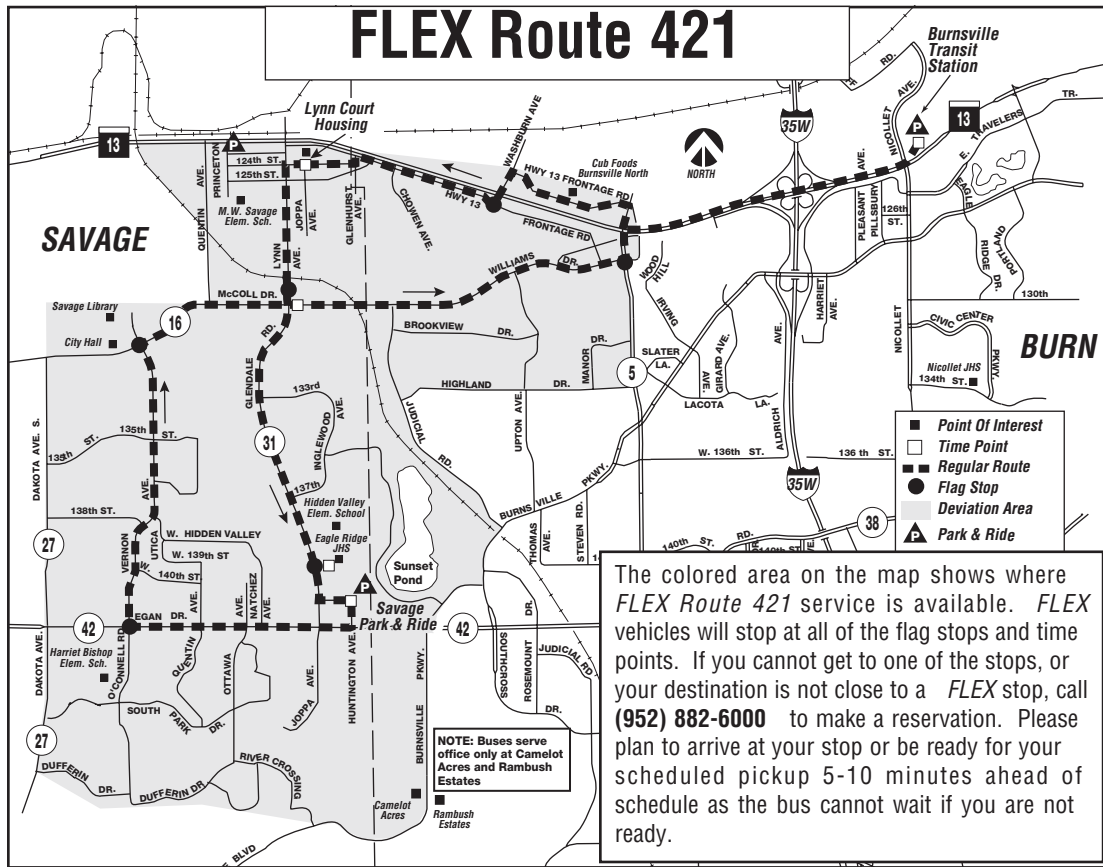


Figure 5-18. Route 421 map.

### Analysis of Passengers per Revenue-Hour versus Transit Use Factors

An analysis was used to assess performance of services in a single region. The community of Margate in Broward County, Florida, demonstrates how a network of suburban services can be developed and what performance can be expected as a result of an areawide analysis.

The relationships between passengers per revenue-hour and such measures as population density, income, the elderly segment of the population, the student-age segment of the population, the number of owner-occupied units, the number of renter-occupied units, and number of car owners were tested at the route level with data derived from the census blocks. The data permitted a Pearson correlation analysis to be conducted to measure the magnitude and sign of these relationships.<sup>2</sup> Findings are summarized in Table 5-4 and include the following:

<sup>2</sup> Hyperstat Online Contents, "Pearson's Correlation," <http://davidmlane.com/hyperstat/A62891.html>: Pearson's correlation reflects the degree of linear relationship between two variables. It ranges from +1 to -1. A correlation of +1 means that there is a perfect positive linear relationship between variables. It is a positive relationship because high scores on the X-axis are associated with high scores on the Y-axis. A correlation of -1 means that there is a perfect negative linear relationship between variables. It is a negative relationship because high scores on the X-axis are associated with low scores on the Y-axis. A correlation of 0 means there is no linear relationship between the two variables.

- The correlation between passengers per revenue-hour and income shows clearly that as the level of income declines, the number of passengers per revenue-hour rises. This noticeable inverse relationship confirms standard transit use theory, which says that lower income, particularly in areas of higher population density, increases transit use.
- The elderly and student-age segments are both positively correlated to passengers per revenue-hour. This finding also confirms transit use theory, though in this sample set, the relationship is minimal to nonsignificant. However,

Table 5-4. Passengers per revenue-hour (pass. rev. hr.) versus transit use factors in Broward County, Florida.

Transit Use Factor	Pearson's Correlation
Pass. Rev. Hr./Income	-0.57648
Pass. Rev. Hr./Elderly Segment	0.061163
Pass. Rev. Hr./Student Segment	0.090209
Pass. Rev. Hr./Population Density	0.83333
Pass. Rev. Hr./Owner-Occupied	-0.39667
Pass. Rev. Hr./Renter-Occupied	0.036481
Pass. Rev. Hr./Owner-Occupied, No Car	0.694742
Pass. Rev. Hr./Owner-Occupied, 1 Car	0.380401
Pass. Rev. Hr./Renter-Occupied, No Car	0.520486
Pass. Rev. Hr./Renter-Occupied, 1 Car	-0.12368

what goes against standard transit use theory is that the correlation between student population and transit ridership is stronger than the correlation between elderly population and transit ridership. The youth were more likely to use transit than the elderly.

- Population density is highly positively correlated to passengers per revenue-hour in the routes analyzed, so standard transit use theory holds firmly in this local circulator setting as well. Higher population density results in higher transit usage.
- The segment of owner-occupied units with no car was strongly correlated to passengers per revenue-hour. This finding is consistent with standard transit use theory, which says that lack of auto ownership increases transit use.
- The segment of owner-occupied units with one car is also positively correlated with passengers per revenue-hour. This might be because the owner-occupied households with only one car have more people in the household with mobility needs that are not being met with a single car. This finding is again consistent with standard transit use theory, which says that lack of auto ownership increases transit use.
- The segment of renter-occupied units with no car is positively correlated with passengers per revenue-hour, once again consistent with the notion that the absence of personal transportation, especially in the case of persons renting units, implies transit use for many trip purposes.
- The segment of renter-occupied units with one car is slightly negatively correlated with passengers per revenue-hour. Thus, as renters obtain personal vehicles, ridership on the shuttle system declines. This finding might reflect that renter-occupied units have fewer people and less travel demand.

It might seem obvious that certain demographic characteristics contribute to better transit ridership, but with such limited experience in the provision of local circulators in primarily suburban settings, it was of value to confirm if normal indicators of transit use potential apply to local circulators as they do to regular fixed-route transit service in a more regional setting. As noted above, there is a *very* strong positive relationship between transit use and population density for the local circulators that were studied. In short, the higher the density, the higher the transit ridership per hour was for the local circulators.

There was also a high positive correlation between lack of car ownership and transit use. Perhaps a little surprising was that the relationship was even stronger for owner-occupied dwellings without cars (0.69) than for renter-occupied dwellings without cars (0.52). As expected, there was also a strong negative correlation (−0.58) between income and transit ridership per hour. In other words, the higher the income,

the lower transit ridership per hour was in the local circulator systems.

Although this study focused on data from only one community—Margate in Broward County, Florida—the results are consistent with typical transit analyses of data from many areas, with the exception of the finding that youth were more likely to use transit than the elderly. This general consistency of findings indicates that measuring similar services within a given geographic area would likely lead to more specific findings.

## Establishing Performance Measurement Programs

Evaluating suburban services is an important component of the successful implementation of suburban services. Not only is it important to ensure that the form of transit is appropriate for the market, but equally important is ensuring that expectations in a community are commensurate with performance. No other form of public transit engenders more local characteristics than suburban transit. Suburban transit is at the local level where the balance between resource expenditures and the need for enhanced service coverage must be determined.

Following is an example of how one agency, in the implementation of a broad family of services, manages performance and expectations for service performance with its stakeholders and the broader community.

Denver RTD has established guidelines in its service standards that the least productive 10% of routes, based on either subsidy per boarding or boardings per hour, need to be evaluated for marketing, revision, or elimination. The same evaluation is applied to routes when both subsidy per boarding *and* boardings per hour fall within the least productive 25%. The calculation of the 10% and 25% standards is made from the annual unweighted data, assuming that the data have a normal distribution and using the appropriate formulas for standard deviation and confidence intervals. However, the standard deviation is applied to the weighted average. Table 5-5 gives the weighted averages and standards by class of service.

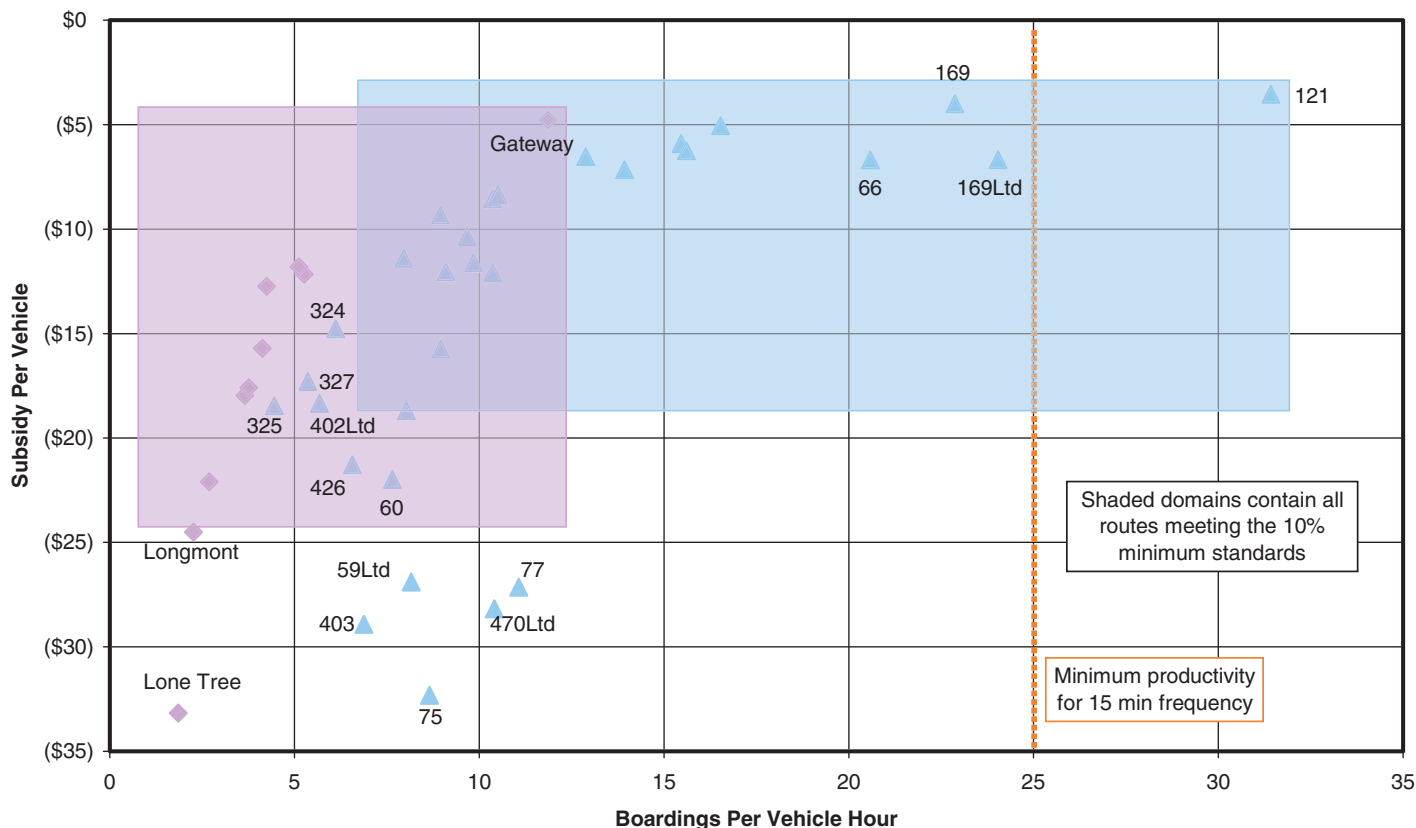
RTD's general approach is as follows. Develop a family of services suited to a variety of markets. Connect all the services together to accommodate the region's dispersed travel patterns. Match the level of service with demand, thereby improving performance and sustainability.

At RTD, "performance" is a term often used interchangeably with "effectiveness" and "efficiency." "Effectiveness" measures attainment of the objective—maximize ridership within the budget—and is presented on the vertical axis of Figure 5-19 as subsidy per vehicle. "Efficiency"—productivity or output/input—is presented on the horizontal axis as boardings per hour.

**Table 5-5. Denver RTD subsidy per boarding and boardings per hour.**

Class of Service	Subsidy per Boarding			Boardings per Hour		
	Average	10% Max.	25% Max.	Average	10% Min.	25% Min.
CBD Local	\$ 2.72	\$ 6.52	\$ 4.71	33.3	18.5	25.6
Urban Local	3.51	11.20	7.53	26.2	14.3	20.0
Suburban Local	7.95	18.48	13.46	14.4	6.6	10.3
Call-n-Ride	14.76	24.38	19.79	4.1	0.7	2.3
Express	6.22	13.86	10.22	28.5	8.8	18.2
Regional	6.82	14.46	10.81	18.2	10.7	14.3
SkyRide	4.26	6.37	5.37	18.3	13.0	15.5
Vanpool	1.19	N/A	N/A	5.2	N/A	N/A

CBD = central business district.



Note: triangles represent fixed routes, and diamonds represent call-and-ride routes.

**Figure 5-19. Denver RTD service performance for suburban local routes and call-n-ride services.**

RTD service standards are depicted in Figure 5-19 to help decision makers make judgments about performance. Each shaded rectangle represents the domain for routes that meet or exceed the 10% minimum performance requirements for that service type. “10% minimum” is defined as meeting or exceeding 10% of the performance for all routes in each category.

RTD’s graph makes it easy to single out poorly performing routes for further evaluation. Other transit agencies can use this graph as a model to create similar graphs relevant to their own areas. By evaluating the suburban services, transit agencies can ensure that expectations in a community are commensurate with performance.



## CHAPTER 6

# Lessons and Conclusions

In the past 20 years, the types of land-use environments in which transit can be applied and be successful have increased. There are now many more land-use environments that support transit in its many forms. There are also many more tools available to agencies to use as part of their planning process to establish transit in their expanding environments. These tools include the use of GIS, which can assist in defining and refining the geographic, population, and market areas to be served. While no substantial patterns have emerged to define with certainty which types of transit will work in specific types of geographic area, the research furthered the knowledge base that transit professionals can use in understanding both the range of transit applications and the expectations for performance.

Transit agencies can use the analysis of the four D's—density, diversity, design, and deterrents to driving—in the further development of suburban services. Analysis of the four D's is understandable for both transit professionals and general decision makers.

Although suburban transit appears to depend heavily on local conditions and expectations, this research can be of assistance to the transit community as the art and science of suburban transit moves past its infancy. The following trends were found for suburban transportation.

### **Operating Environments**

Suburban environments are diverse. This diversity includes differences in markets to be served, as well as differences in the physical environment. Successful suburban service has creatively adapted transit practice to complement local landscapes. Clearly, these findings support the continued integration of land-use planning and transit service planning as a means to continually strengthen transit's ability to serve the ever-expanding suburban environments. Understanding the operating environment is increasingly important for transit professionals. GIS tools can be used substantially in this regard to display both physical and market attributes of the suburban environments, such that the types of services implemented can

complement both the market and the regions. The four D's—design, density, diversity, and deterrents to driving—can be readily adapted to local environments and conditions.

### **Measurement and Evaluation Processes**

Measurement and evaluation processes need to reflect local priorities and conditions. What is deemed successful is a local issue, but transit professionals can educate local policy boards and communities to ensure that expectations for performance are understood. Denver RTD presents a clearly defined evaluation and performance measuring process for its services. A process such as this can provide both transit staff and policy boards with an informed knowledge base and help establish standards to be shared with the community. This process is particularly important because the development and sustainability of suburban services are now more than ever dependent on local investment, whether public or private.

This study clearly points to more comprehensive service monitoring and evaluation programs as a means to move the practice forward. Currently, because of budget and time constraints, evaluation is often an afterthought. To properly assess and control the provision of service, from both a customer and a cost investment perspective, it is essential for the transit community to understand and clarify its service performance expectations and to educate its policy boards and communities as to these expectations. The expectations must be understood and communicated if investments are to continue to the level that will be required.

### **Innovations**

There have been many innovations in the area of suburban transit, ranging from financial partnerships to the use of technology in the implementation of service. These innovations will and should continue as they expand the opportunities available to the transit community.

Real-time information is a service to both customers and operators. Direct communication between operators and customers has enhanced transit's ability to serve its markets more effectively and ultimately made transit more competitive and convenient.

Financial partnerships now include private investment in capital resources and operating costs. Municipal investments are also a growing phenomenon, with local communities either (a) partnering with transit agencies to provide enhanced coverage to nontransit neighborhoods or (b) opting on their own to supply resources for public transit access. Many suburban services are developed with the goal of expanding transit service coverage, which sometimes counters the typical goal of fixed-route service, which is to maximize productivity.

Some suburban transit services incorporate the responsibility to deliver ADA complementary paratransit services by blending ADA-eligible clients into the suburban service solutions, thus eliminating the need for the separate ADA service.

## **Future Research**

There were clear limitations of the research, mainly the inability to extend the findings of local case studies to a national format. The best use of this research approach is at the local level, with an emphasis on strengthening the relationship between land-use planning and transit planning. At the local level, this approach can be a valuable tool in furthering suburban transit planning.

Additional research could focus on suburban alternatives to fixed-route service. In many communities, but primarily in suburban communities, alternatives to fixed-route service are an increasingly prevalent means of expanding service coverage. These alternatives may also have the potential to further the federal priority of coordinating human services with public transit programs. Further research could also examine suburban transit alternatives for ADA paratransit service, because costs continue to outpace demand for ADA paratransit service in both urban and suburban locales.

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*Abbreviations and acronyms used without definitions in TRB publications:*

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation