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CENTER FOR TRANSPORTATION RESEARCH

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Development of an Accessibility Formulation to Measure Customers' Evaluations of Demand-Responsive Transit (DRT) Systems: Final Report

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16. Abstract This report discusses the application of the paratransit microsimulation patron accessibility analysis tool developed by the University of Texas researchers. The research team worked on updating the DRT Accessibility Tool developed by the Texas Department of Transportation's Public Transportation Division in Project 5-5178. The primary objectives of this research are (1) classifying the rural transit districts into five distinct categories, (2) updating the DRT Accessibility Tool to make it customizable for each of the five categories, and (3) developing "what if" scenarios for the tool to test. The customization of the tool will make it functional for applications in all the rural transit districts in Texas.		
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Chapter 1. Demand-Responsive Transit Service and Characteristics

1.1 Introduction

Demand-responsive transit (DRT) services, sometimes referred to as paratransit or dial-a-ride, typically provide transportation on demand for mobility-impaired, low-income, and elderly populations in rural areas. DRT service is most common in five types of markets (see Speilberg and Pratt, 2004):

1) Rural areas not dense enough to support a fixed route transit system,
2) Urban areas acting independently of a fixed route transit system (regular transit service),
3) Urban areas requiring these services during off-peak times such as evenings and weekends,
4) Urban areas needing a feeder for a fixed route transit system, and
5) As complementary services required by the 1991 Americans with Disabilities Act (ADA) for mobility-impaired populations.

Generally, DRT services are provided when a patron calls the transit operator at least 24 hours in advance of the requested ride in order to schedule a pick-up time. The operator then uses optimization software to create vehicle routes for each day based on the ride requests and characteristics of their service capabilities. In turn, DRT vehicle drivers receive and execute this route schedule. The dimensions of service vary widely from one agency to another. For example, some system operators provide point-to-point service, transporting patrons to and from specific points like a taxi. Others provide route deviation service, picking up and dropping off patrons at specific locations but always returning to a loosely defined route, much like a bus. Service can be further customized by choosing to pick up and drop off patrons at the requested origins/destinations, at convenient locations (including a fixed-route bus stop), or any combination of these (Spielberg and Pratt, 2004).

DRT is particularly important in Texas, where 177 of 254 counties are rural and over 15% of the state population lives in rural areas (U.S. Census, 2010). In fact, Texas has 39 distinct rural transit districts that plan and operate DRT services throughout the state (see Figure 1.1). Table 1.1 presents a complete list of the 39 DRT providers, along with the name of the DRT service if supplied (not all DRT services have their own names). A detailed list of the counties each agency serves is in Appendix A.[1]

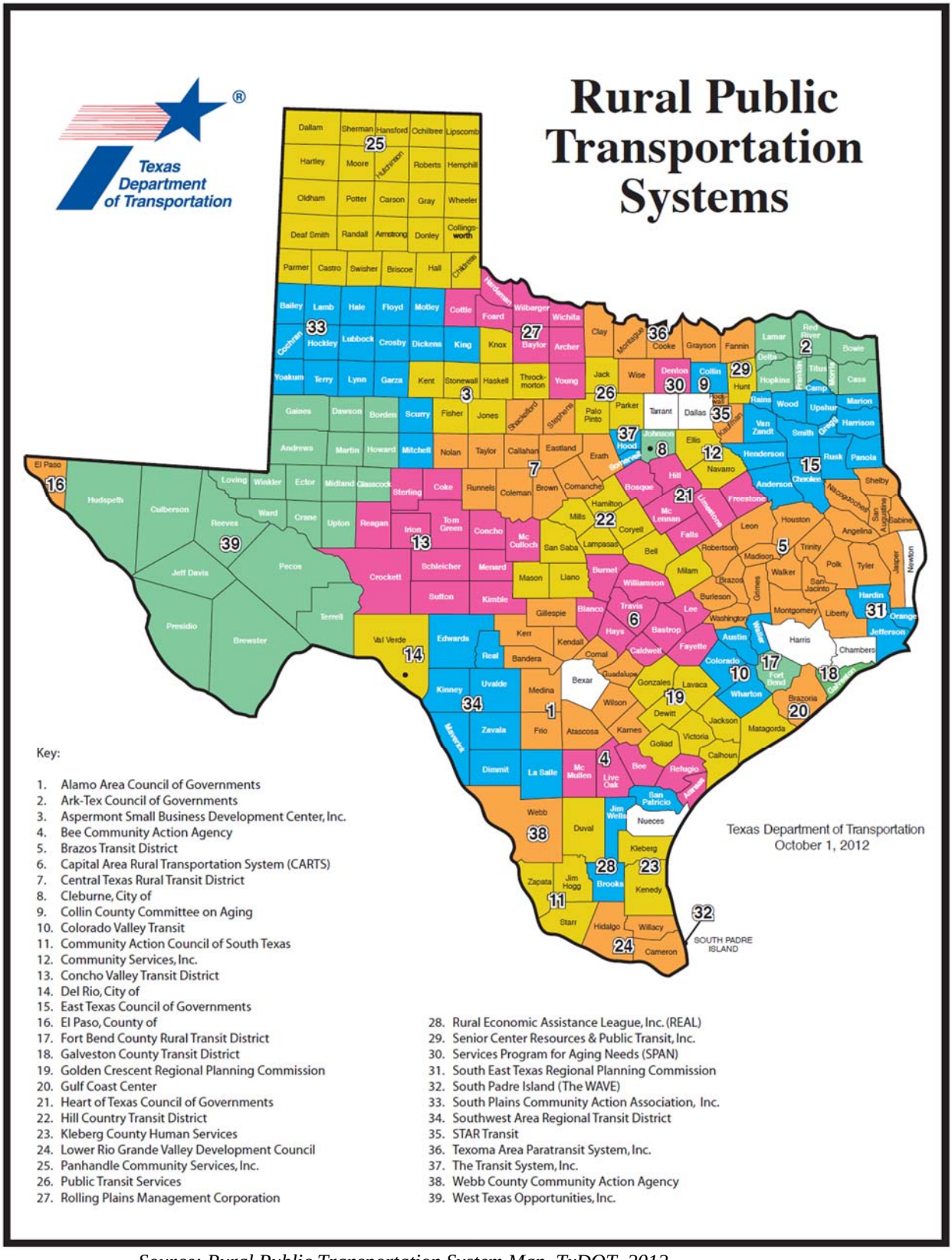
[1] TxDOT's *Rural Public Transportation System Map* indicates that 39 DRT agencies operate in Texas. However, during the data collection process the research team found that two of these agencies are no longer providing DRT services. Therefore, we collected information on 37 agencies only (more details in Section 2.1).

In this context, the Texas Department of Transportation's (TxDOT) Public Transportation Division (PTN) developed a DRT tool to evaluate the current accessibility levels for various combinations of population groups, times of day, and travel purposes and to undertake "what if?" scenario analyses to evaluate changes in fleet characteristics, population demographics, and service areas and operators. The tool is designed to predict riders' future needs.

The current DRT tool uses data exclusively from the Brownsville urbanized area. However, the underlying DRT demand behavior and patterns in Brownsville reflect DRT's role as a means of fulfilling the agency's ADA requirements as a complement to its fixed route service. Consequently the Brownsville data are not likely to be transferable to other rural DRT regions in Texas where the focus is on the general public.

One objective of this project was to collect information on key aspects of DRT service in each of the 39 rural transit districts (and then use this information to update the TxDOT DRT tool). Using the knowledge gained from this effort, this chapter identifies salient DRT service dimensions that, when taken together, comprehensively characterize DRT service. Based on these dimensions, the researchers developed a typology of DRT services and their operational/planning contexts.

The remainder of this chapter is organized as follows. Section 1.2 provides information on key aspects of DRT service in each of the 39 rural transit districts. Section 1.3 presents a typology of DRT services. The final section discusses the typology defined in Section 1.3.



Source: Rural Public Transportation System Map, TxDOT, 2012

Figure 1.1: Rural public transportation systems in Texas

Table 1.1: List of rural transit districts and transit service names

No.	Rural Transit District	Transit Service Name
1	Alamo Area Council of Governments (AACOG)	Alamo Regional Transit (ART)
2	Ark-Tex Council of Governments (ATCOG)	ARK-TEX TRAX
3	Aspermont Small Business Development Center	Double Mountain Coach
4	Bee Community Action Agency (BCAA)	Bee Transit
5	Brazos Transit District	Brazos Transit
6	Capital Area Rural Transportation System (CARTS)	CARTS
7	Central Texas Rural Transit District	City and Rural Rides (CARR)
8	Cleburne, City of	Cletran Transportation System
9	Collin County Committee on Aging (CCART)	CCART
10	Colorado Valley Transit	Colorado Valley Transit
11	Community Action Council of South Texas (CACST)	Rainbow Lines
12	Community Services, Inc.	Community Services
13	Concho Valley Transit District	Thunderbird Transit
14	Del Rio, City of	City of Del Rio
15	East Texas Council Of Governments (ETCOG)	GoBus
16	El Paso, County of	El Paso County Rural Transit
17	Fort Bend County Rural Transit District	Fort Bend Transit
18	Galveston County Transit District	Island Transit
19	Golden Crescent Regional Planning Association (GCRPC)	RTRANSIT
20	Gulf Coast Center	Connect Transit
21	Heart of Texas Council of Governments (HOTCOG)	Heart of Texas Rural Transit District (HOTRTD)
22	Hill Country Transit District	The HOP
23	Kleberg County Human Services	Paisano Express
24	Lower Rio Grande Valley Development Council	Valley Metro
25	Panhandle Community Services, Inc. (PCS)	Panhandle Rural Transportation
26	Public Transit Services	Public Transit Services
27	Rolling Plains Management Corporation (RPMC)	SHARP Lines
28	Rural Economic Assistance League, Inc. (REAL)	REAL Transit
29	Senior Center Resources and Public Transit, Inc. (SCRPT)	The Connection Public Transit
30	Services Program for Aging Needs (SPAN)	SPAN
31	South East Texas Regional Planning Commission (SETRPC)	South East Texas Transit (SETT)
32	South Padre Island	The WAVE
33	South Plains Community Action Association, Inc. (SPCAA)	SPARTAN Transit
34	Southwest Area Regional Transit District	-
35	STAR Transit	STAR Transit
36	Texoma Area Paratransit System, Inc.	TAPS
37	The Transit System, Inc.	MyRide
38	Webb County Community Action Agency	El Aguila Rural Transportation
39	West Texas Opportunities, Inc. (WTO)	WTO, I TRAX

1.2 DRT Characterization

1.2.1 Data Collection Process

The data collection process was conducted in two steps. First, the research team collected information from the agencies' official websites. Second, agencies that do not have a website or whose sites did not provide a full description of services were contacted by email and/or phone. The data collection process started in November 2012 and ended in February 2013. Table 1.2 lists the sources of data used. The DRT agencies' websites and contact information are provided in Appendix B.

During the data collection process, the research team found that three of the 39 agencies do not provide DRT services:

- Community Services, Inc. (agency No. 12): The counties that were covered by Community Services, Inc. (Ellis and Navarro) are now covered by STAR Transit (agency No. 35).
- County of El Paso (agency No. 16): No DRT service operates in El Paso County. The county operates only a fixed route bus service.
- South Padre Island (agency No. 32): The agency serves only Fort Isabel and the island and offers route deviation and flexible routes.

To maintain the agencies' numeration code established by TxDOT (established in Figure 1.1 and Table 1.1), in this report's tables we will present information for the 39 agencies, but the cells pertaining to Community Services Inc., the County of El Paso, and South Padre Island will be always left blank.

Table 1.2: Sources of data

No.	DRT Agency	Website	Phone	Email
1	Alamo Area Council of Governments (AACOG)	x	x	
2	Ark-Tex Council of Governments (ATCOG)	x	x	
3	Aspermont Small Business Development Center		x	
4	Bee Community Action Agency (BCAA)		x	
5	Brazos Transit District	x		x
6	Capital Area Rural Transportation System (CARTS)	x		x
7	Central Texas Rural Transit District	x		x
8	Cleburne, City of	x	x	x
9	Collin County Committee on Aging (CCART)			x
10	Colorado Valley Transit	x	x	
11	Community Action Council of South Texas (CACST)	x	x	
12	Community Services, Inc.	-	-	-
13	Concho Valley Transit District	x	x	
14	Del Rio, City of	x	x	
15	East Texas Council Of Governments (ETCOG)	x		x
16	El Paso, County of	-	-	-
17	Fort Bend County Rural Transit District	x		x
18	Galveston County Transit District	x		
19	Golden Crescent Regional Planning Association (GCRPC)	x		x
20	Gulf Coast Center	x	x	x
21	Heart of Texas Council of Governments (HOTCOG)	x	x	
22	Hill Country Transit District	x		x
23	Kleberg County Human Services	x		x
24	Lower Rio Grande Valley Development Council	x		x
25	Panhandle Community Services, Inc. (PCS)		x	
26	Public Transit Services	x	x	
27	Rolling Plains Management Corporation (RPMC)	x	x	
28	Rural Economic Assistance League, Inc. (REAL)	x	x	
29	Senior Center Resources and Public Transit, Inc. (SCRPT)	x		x
30	Services Program for Aging Needs (SPAN)	x		x
31	South East Texas Regional Planning Commission (SETRPC)	x		x
32	South Padre Island			
33	South Plains Community Action Association, Inc. (SPCAA)			x
34	Southwest Area Regional Transit District	x		x
35	STAR Transit	x	x	
36	Texoma Area Paratransit System, Inc.	x	x	
37	The Transit System, Inc.	x	x	
38	Webb County Community Action Agency	x		x
39	West Texas Opportunities, Inc. (WTO)	x		x

1.2.2 DRT Service Dimensions

The research team identified the salient DRT service dimensions that, when taken together, comprehensively characterize DRT service. These dimensions were selected based on previous experience in studying DRT services and the information provided by agencies through their websites or by email/phone. These dimensions include the following:

- Rider destinations
- Vehicle fleet type
- Vehicle characteristics
- Spatial coverage
- Route type
- Origin-destination services
- Schedule

Table 1.3 presents our characterization of the 39 DRT services in Texas, with the DRT agencies appearing as columns and the salient dimensions appearing as rows. An "x" in a cell indicates that the provider in that column offers a service of the kind denoted in that row. Some DRT services offer more than one type of service within the dimension. For example, agency No. 1, AACOG, serves all markets, while agency No. 2, ATCOG, serves only the markets "general medical assistance," "work," "shopping," and "recreation."

The sections following Table 1.3 describe each DRT service dimension, along with findings and comments regarding the information presented in the table.

1.2.3 Rider Destinations

The first aspect of the DRT service studied is rider destination. Destinations are important in understanding the reach of DRT services and evaluating whether the agencies are flexible regarding trip purposes. This project considered the following seven general destinations:

- **Seniors:** Transportation to elderly-specific locations, such as adult day care facilities, adult day health care facilities, nutrition centers, retirement homes, active-living senior housing, or adult programs that invite seniors to socialize and recreate.
- **Medical appointments:** Transportation to any doctor's/dentist's office or medical center (hospitals, health centers, medical centers, emergency rooms, nutritional visits), exclusive of Medicaid appointments
- **Medicaid appointments:** Medicaid is a health and long-term care coverage program that is jointly financed by states and the federal government. There are strict eligibility requirements to qualify for free transportation to pre-approved medical appointments. For transit agencies

with Medicaid contracts, unique contractual requirements often have a strong impact on trip scheduling activities as a whole. For this reason, it is included on this destination list.

- **Work:** A number of agencies offer transportation for work purposes. This market differs from others because workers need to reach their destination at a specific time, which makes the DRT operation more complex.
- **Shopping/personal services:** Includes grocery, pharmacy, beauty and barber shop appointments, clothing and recreational shopping, among other services.
- **Educational centers:** Includes high schools, colleges, and other learning centers.
- **Recreation:** This category encompasses a wide variety of locations, such tourist destinations, visiting friends and family, etc.

According to the information in Table 1.3, most agencies serve all markets. In fact, almost all the agencies transport people to work, shopping, and recreation locations. However, some restrictions arise for medical purposes (medical appointments vs. Medicaid) and for senior-related locations. These restrictions may be associated with vehicle characteristics or personnel training.

1.2.4 Vehicle Fleet Type

Vehicle fleet type was obtained from the National Transit Database (NTS, 2011)[2] and includes

- Vans
- Cutaways
- Buses

Agencies can have more than one vehicle type (see, for example, agency No. 1, which operates both vans and cutaways), although not necessarily all the vehicles within the same type have the same capacity. For example, agency No. 1 has vans of different sizes, while agency No. 9 has vans of only one size. We do not provide more details on this issue because is not relevant for constructing the typology.

The information on vehicle fleet type (and vehicle fleet characteristics, discussed in Section 1.2.3) should be used carefully. We are reporting the vehicle types available by the agencies, but not the vehicle types that the agencies operate on a daily basis. For example, an agency may have buses in their fleet, but they may keep them parked and rarely use them for service. Additionally, a segment of the fleet may not be available for operation (due to maintenance/mechanical considerations, for example).

[2] The information in the National Transit Database was collected for year 2011. We are assuming that the agencies haven't modified their fleet substantially during the last year.

Table 1.3 shows that most agencies operate fleets with multiple types of vehicles. Vans are the most common vehicle type (30 agencies have vans), followed by cutaways (25 agencies have cutaways), and buses (only 16 agencies have buses).

1.2.5 Vehicle Fleet Characteristics

These fleet characteristics were obtained from the National Transit Database (NTS, 2011):

- Average fleet age in years
- Fleet size in vehicles
- Average vehicle capacity in seats per vehicle

The vehicles used for DRT services are moderately old, with an average of 6.4 years and a standard deviation of almost 2 years. The agency with newest vehicles is Kleberg County Human Services (agency No. 23), with an average fleet age of 2.8 years. Several agencies' fleets are over/almost 10 years old, including Colorado Valley Transit (agency No. 10), Concho Valley Transit District (agency No. 13), RPMC (agency No. 27), South Padre Island (agency No. 32), and Webb County Community Action Agency (agency No. 38). The average fleet size is 51.7 vehicles and the average capacity is 14.8 passengers per vehicle. These numbers are consistent with the vehicle fleet types (see Section 1.2.2), given that the most common vehicle types (van and cutaways) are characterized by moderate to low seat capacities.

As with vehicle fleet types, the figures provided in Table 1.3 indicate only the vehicles that each agency owns, not necessarily the vehicles regularly used (see discussion in Section 1.2.2 and footnote 2).

1.2.6 Spatial Coverage

The first aspect of spatial coverage considered is area served (in square miles), calculated by summing the areas of all counties served by each agency (Appendix A specifies the counties each agency covers). Coverage is an important dimension of DRT services, affecting the agencies' daily operations. For example, agencies operating in smaller areas can have more flexible routes than agencies covering larger areas, because route deviations will cover smaller distances.

The other aspect considered was whether the service is limited to a rural area, or extended to trips in nearby urban areas. The agencies providing transportation to nearby urban areas were further categorized by whether they provided full service in the urban area or simply connected with urban transit systems, providing partial urban service. These categories (within rural area only, full coverage of urban areas, and partial coverage in urban areas) are exclusive.

According to Table 1.3, most agencies cover urban areas, either fully or partially. Some agencies (City of del Rio [agency No. 14], PCS [agency No. 25], and STAR Transit [agency No. 35]) have limitations regarding their spatial coverage, and transport passengers to urban areas only for medical purposes.

1.2.7 Route Type

Another essential DRT characteristic is whether the service operates with a fixed route, a route with deviations, or a flexible route.

- A **fixed route service** operates between two fixed endpoints on a fixed schedule over a predefined route. The service is for individuals who can walk or roll to a vehicle stop, and board and exit a vehicle with or without a mobility device. To comply with the ADA, this type of service must provide a demand response component for persons with disabilities who cannot reach a bus stop.
- In a **route with deviations,** vehicles operate on a regular schedule along a well-defined path, with or without marked bus stops; the route may deviate to serve demand-responsive requests within a zone around the path. The width or extent of the zone may be precisely established or flexible. May or may not be solely for ADA purposes.
- **Flexible routes** have vehicles operating in conventional fixed-route, fixed-schedule mode, but switching to demand-responsive operation for a limited portion of the route. May or may not be solely for ADA purposes.
- **Demand response** has no set schedule or route for a vehicle. Its travel paths are solely in response to advance calls for transportation.

Answers here were varied. Some agencies offer different styles of service depending on whether the destinations are in urbanized or rural areas, or by county lines. Statewide, DRT is the common service type of rural transit agencies, but many also had transit offerings of other routing styles, as shown in Table 1.3.

1.2.8 Origin-Destination Service

Another consideration is the type of origin-destination provided by the agency: either door-to-door or curb-to-curb. Passengers with limited mobility may notice the difference in service between being offered door-to-door service and being delivered curb-to-curb. This dimension of service can also affect the planning of the service, as door-to-door deliveries are likely to be more individualized and time consuming. Door-to-door services, however, are not very common (only 12 agencies offer this service).

1.2.9 Schedule

Another dimension of service highly relevant to potential passengers is availability: the days and times of service. Agency websites generally contain schedule information but some schedules are unexpectedly complex. Some agencies serve a multi-county area, and service between certain counties may be provided on a different frequency than travel in-county. Time of service also varies between agencies: some indicated that the time when the first pick-up might be made, while others indicated the time of the first drop-off. Another agency indicated general times of service, while specifying that extended hours may be

arranged as needed. At least one agency offered extended summer hours. Although part of our information collection occurred in November and December, the websites mentioned no extra hours for the holiday season.

Table 1.3: DRT service dimensions

DRT service dimensions		1. AACOG	2. ATCOG	3. Aspermont Small Business Development Center	4. BCAA	5. Brazos Transit District
Rider destinations	Adult day care	x	x	x	x	x
	General medical assistance	x	x	x	x	x
	Medicaid	x		x		x (3)
	Work	x	x	x	x	x
	Shopping	x	x	x	x	x
	Educational centers	x	x	x	x	x
	Recreation	x	x	x	x	x
Vehicle fleet type	Vans	x	x	x	x	
	Cutaways	x	x	x	x	x
	Buses					x
Vehicle fleet characteristics	Average fleet age (years)	7.8	4.3	6.7	4.2	7.7
	Fleet size (vehicles)	102	58	19	26	58
	Average vehicle capacity (seats/vehicle)	1,180	598	178	242	3,220
Spatial coverage	Area served (sq. miles)	12	10	9	9	28
	Within rural area only	10,116	5,732	6,313	4,082	16,053
	Full coverage in urban areas		x			
	Partial coverage in urban areas					x
Route type	Fixed route	x		x	x	
	Route deviation					x
	Flexible route		x			
	DRT service	x	x	x	x	
Origin-destination service	Door-to-door available	x	x	x	x	x
	Curb-to-curb	x				
Schedule	Monday–Friday	x	x	x	x	x
	Saturday	7AM - 6PM	8AM - 5PM	5AM - 7PM	7AM - 4PM (7)	5AM - 7PM
	Sunday	No service	No service	5AM - 7PM	No service	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

Table 1.3: DRT service dimensions (continuation)

DRT service dimensions		6. CARTS	7. Central Texas Rural Transit District	8. Cleburne, City of	9. CCART	10. Colorado Valley Transit
Rider destinations	Adult day care	x	x	x	x	x
	General medical assistance	x	x	x	x	x
	Medicaid	x (3)	x	x	x	
	Work	x	x	x	x	x
	Shopping	x	x	x	x	x
	Educational centers	x		x	x	x
	Recreation	x	x	x	x	x
Vehicle fleet type	Vans	x	x	x	x	
	Cutaways	x	x		x	x
	Buses	x		x		
Vehicle fleet characteristics	Average fleet age (years)	4.7	5.0	4.8	6.8	10.3
	Fleet size (vehicles)	162	63	21	30	30
	Average vehicle capacity (seats/vehicle)	2,784	1,156	285	443	500
Spatial coverage	Area served (sq. miles)	17	18	14	15	17
	Within rural area only	7,503	10,743	725	841	3,340
	Full coverage in urban areas	x				
	Partial coverage in urban areas		x		x	
Route type	Fixed route			x		x
	Route deviation					
	Flexible route					x (6)
	DRT service	x	x	x	x	x (6)
Origin-destination service	Door-to-door available	x	x	x	x	x
	Curb-to-curb					
Schedule	Monday–Friday	x	x	x	x	x
	Saturday	7AM - 4PM (7)	5:30AM - 7PM	7AM-6PM (7)	6AM - 6PM	8AM - 5PM
	Sunday	7AM - 4PM (7)	5:30AM - 7PM	7AM-6PM (7)	No service	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

Table 1.3: DRT service dimensions (continuation)

DRT service dimensions		11. CACST	12. Community Services, Inc.	13. Concho Valley Transit District	14. Del Rio, City of	15. ETCOG
Rider destinations	Adult day care		x	x	x	x
	General medical assistance	x	x	x	x	x
	Medicaid			x (3)	x	
	Work	x	x	x	x	x
	Shopping	x	x	x	x	x
	Educational centers	x	x	x	x	x
	Recreation		x	x	x	x
Vehicle fleet type	Vans	x		x	x	x
	Cutaways	x	x		x	x
	Buses			x	x	
Vehicle fleet characteristics	Average fleet age (years)	5.4	3.7	12.5	7.1	6.2
	Fleet size (vehicles)	30	20	71	22	66
	Average vehicle capacity (seats/vehicle)	431		1,069	278	784
Spatial coverage	Area served (sq. miles)	14	15	15	13	12
	Within rural area only	5,151	1,945	15,358	3,145	9,687
	Full coverage in urban areas			x	x	x
	Partial coverage in urban areas					
Route type	Fixed route	x	x		x (4)	
	Route deviation			x (5)	x (5)	
	Flexible route					x
	DRT service	x	x	x	x	
Origin-destination service	Door-to-door available	x	x	x	x	x
	Curb-to-curb	x	-		x	
Schedule	Monday–Friday	x	-	x	x	x
	Saturday	7AM - 5:30PM	5AM - 5:30PM	6:30AM - 6:30PM	6AM - 7PM	6AM - 7PM (7)
	Sunday	No service	No service	7:30AM - 6:30PM	No service	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

Table 1.3: DRT service dimensions (continuation)

DRT service dimensions		16. El Paso, County of	17. Fort Bend County Rural Transit District	18. Galveston County Transit District	19. GCRPC	20. Gulf Coast Center
Rider destinations	Adult day care	-	x	x	x	x
	General medical assistance	-	x	x	x	x (2)
	Medicaid	-			x	
	Work	-	x	x	x	x
	Shopping	-	x	x	x	x
	Educational centers	-		x	x	x
	Recreation	-		x	x	x
Vehicle fleet type	Vans	-	x	x	x	x
	Cutaways	-				
	Buses	-	x	x	x	x
Vehicle fleet characteristics	Average fleet age (years)	-	5.3	5.8	4.6	7.1
	Fleet size (vehicles)	-	47	43	65	41
	Average vehicle capacity (seats/vehicle)	-	940	1,056	889	619
Spatial coverage	Area served (sq. miles)	-	20	25	14	15
	Within rural area only	-	862	378	6,016	1,358
	Full coverage in urban areas	-				
	Partial coverage in urban areas	-	x	x	x	
Route type	Fixed route	-				x
	Route deviation	-		x		
	Flexible route	-	x			
	DRT service	-	x	x	x	x
Origin-destination service	Door-to-door available	-	x	x	x	x
	Curb-to-curb	-	x			
Schedule	Monday–Friday	-	x	x	x	x
	Saturday	-	7:30AM - 5:30PM	6AM - 11:30PM	7AM - 10PM	6:30AM - 5:30PM
	Sunday	-	No service	6AM - 11:30PM	7AM - 7PM	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

Table 1.3: DRT service dimensions (continuation)

DRT service dimensions		21. HOTCOG	22. Hill Country Transit District	23. Kleberg County Human Services	24. Lower Rio Grande Valley Development Council	25. PCS
Rider destinations	Adult day care	x	x	x	x	x
	General medical assistance	x	x	x	x	x
	Medicaid			x		x
	Work	x	x	x	x	x
	Shopping	x	x	x	x	x
	Educational centers	x	x	x	x	x
	Recreation	x	x	x	x	x
Vehicle fleet type	Vans	x	x	x		x
	Cutaways	x	x	x		x
	Buses		x		x	
Vehicle fleet characteristics	Average fleet age (years)	6.3	7.0	2.8	6.9	5.3
	Fleet size (vehicles)	52	145	14	27	69
	Average vehicle capacity (seats/vehicle)	536	2,208	110	638	1,040
Spatial coverage	Area served (sq. miles)	10	15	8	24	15
	Within rural area only	5,528	8,415	2,340	3,052	25,753
	Full coverage in urban areas	x				x
	Partial coverage in urban areas			x		
Route type	Fixed route		x		x	x (4)
	Route deviation		x (5)			
	Flexible route				x	
	DRT service		x	x		x
Origin-destination service	Door-to-door available	x	x	x	x	x
	Curb-to-curb		x			
Schedule	Monday–Friday	x	x	x	x	x
	Saturday	6AM - 6PM	6AM - 7PM	8AM - 11:30AM; 1:30PM - 4PM	6AM - 8PM	8AM - 5PM
	Sunday	No service	9AM - 6PM	No service	6AM - 8PM	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

Table 1.3: DRT service dimensions (continuation)

DRT service dimensions		26. Public Transit Services	27. RPMC	28. REAL	29. SCRPT	30. SPAN
Rider destinations	Adult day care	x		x	x	x
	General medical assistance	x	x	x	x	x (2)
	Medicaid	x	x		x	x
	Work	x		x	x	x
	Shopping	x	x (1)	x	x	x
	Educational centers	x		x		x
	Recreation	x	x	x		x
Vehicle fleet type	Vans	x	x	x		x
	Cutaways		x	x	x	
	Buses	x				x
Vehicle fleet characteristics	Average fleet age (years)	8.0	9.2	4.7	4.8	6.0
	Fleet size (vehicles)	32	39	49	13	33
	Average vehicle capacity (seats/vehicle)	396	500	616	180	455
Spatial coverage	Area served (sq. miles)	12	13	13	14	14
	Within rural area only	2,766	6,584	2,502	840	878
	Full coverage in urban areas					
	Partial coverage in urban areas	x	x	x	x	x
Route type	Fixed route					
	Route deviation					
	Flexible route	x		x		
	DRT service		x		x	x
Origin-destination service	Door-to-door available	x	x	x	x	x
	Curb-to-curb	x		x		x
Schedule	Monday–Friday	x	x	x	x	x
	Saturday	8AM - 5PM	8AM - 5PM (7)	8AM - 5PM (7)	7AM - 7PM	7AM-6PM
	Sunday	No service	No service	No service	No service	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

Table 1.3: DRT service dimensions (continuation)

DRT service dimensions		31. SETRPC	32. South Padre Island	33. SPCAA	34. Southwest Area Regional Transit District	35. STAR Transit
Rider destinations	Adult day care			x	x	x (1)
	General medical assistance	x	x	x	x	x (2)
	Medicaid			x	x	x
	Work	x	x	x	x	x
	Shopping	x	x	x	x	x
	Educational centers	x	x	x		x
	Recreation	x	x	x	x	x
Vehicle fleet type	Vans	x		x	x	x
	Cutaways	x	x	x		x
	Buses			x		N/A
Vehicle fleet characteristics	Average fleet age (years)	4.1	4.5	9.0	N/A	3.2
	Fleet size (vehicles)	46	10	57	N/A	52
	Average vehicle capacity (seats/vehicle)	657	200	1,140	N/A	N/A
Spatial coverage	Area served (sq. miles)	14	20	20	N/A	14
	Within rural area only	2,101	209	17,212	11,122	908
	Full coverage in urban areas		x			x
	Partial coverage in urban areas	x		x	x	
Route type	Fixed route					x (4)
	Route deviation					
	Flexible route		x		x	
	DRT service	x	x			x
Origin-destination service	Door-to-door available	x	x	x	x	x
	Curb-to-curb			x	x	x
Schedule	Monday–Friday	x	x	x	x	x
	Saturday	8AM - 4PM (7)	7AM - 9PM (7)	7AM - 6PM	7AM-6PM	8AM - 5PM (7)
	Sunday	No service	7AM - 9PM (7)	7AM - 6PM	7AM-6PM	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

Table 1.3: DRT service dimensions (continuation)

DRT service dimensions		36. Texoma Area Paratransit System, Inc.	37. The Transit System, Inc.	38. Webb County Community Action Agency	39. WTO
Rider destinations	Adult day care	x	x		x
	General medical assistance	x	x	x	x
	Medicaid		x		x
	Work	x	x	x	x
	Shopping	x	x		x
	Educational centers	x	x	x	x
	Recreation	x	x	x	x
Vehicle fleet type	Vans	x	x	x	x
	Cutaways		x	x	x
	Buses	x			
Vehicle fleet characteristics	Average fleet age (years)	6.1	7.3	9.1	6.0
	Fleet size (vehicles)	54	17	15	104
	Average vehicle capacity (seats/vehicle)	891	246	232	918
Spatial coverage	Area served (sq. miles)	17	14	15	9
	Within rural area only	5,622	607	3,362	44,131
	Full coverage in urban areas	x			
	Partial coverage in urban areas		x	x	x
Route type	Fixed route				
	Route deviation	x			
	Flexible route				
	DRT service		x	x	x
Origin-destination service	Door-to-door available	x	x	x	x
	Curb-to-curb				
Schedule	Monday-Friday	x	x	x	x
	Saturday	5AM - 5PM (7)	7AM - 6PM	5:30AM - 8:30PM	8AM - 5PM
	Sunday	No service	No service	5:30AM - 8:30PM	No service

(1) DRT service for this purpose is only available within the county
(2) Medical services provided only in some counties and/or for veterans only
(3) Medicaid free
(4) For medical purposes only
(5) Fixed route only in urban areas
(6) Different route types for different areas
(7) Hours of operation vary by location and/or trip purposes

1.3 DRT Typology

Based on the DRT service dimensions presented in Section 1.2, we have developed a typology of DRT services. While each of the 39 rural transit providers is likely to possess unique features, the intent here is to group the providers into smaller sets of DRT types based on their similarities in terms of the described dimensions of the DRT service and the operation/planning contexts. We have identified five distinct types of DRT services, which are presented in Table 1.4. In the sections following the table, we discuss the salient aspects of each category.

Table 1.4: Typology definition

Category No.	Category label	Category characterization		DRT Agencies	
		Main characteristics	Secondary characteristics	No.	Name
1	Small Areas	- Area served < 1,000 sq. miles - Full coverage in urban areas - Flexible route type in most areas	- Buses are more commonly used than in other categories - Young fleet (less than 6 years on average) - Small fleet (less than 30 vehicles on average)	8	Cleburne, City of
				9	CCART
				17	Fort Bend County Rural Transit District
				18	Galveston County Transit District
				29	SCRPT
				30	SPAN
				18	Galveston County
				37	The Transit System, Inc.
2	Medium Areas	- Area served between 1,000 sq. miles and 8,000 sq. miles - Full coverage in urban areas - Flexible routes or route deviation	- Relatively late (8AM) opening time - No service during weekends in most areas - Small vehicle capacity (12 seats per vehicle on average)	19	GCRPC
				23	Kleberg County Human Services
				26	Public Transit Services
				27	RPMC
				28	REAL
3	Large Areas	- Area served > 8,000 sq. miles - Flexible route type in most areas	- No service on Sundays, some agencies operate on Saturdays - Large fleet (more than 85 vehicles on average)	1	AACOG
				5	Brazos Transit District
				7	Central Texas Rural Transit District
				22	Hill Country Transit District
				25	PCS
				33	SPCAA
				34	Southwest Area Regional Transit District
				39	WTO

Table 1.4: Typology definition (continuation)

Category No.	Category label	Category characterization		DRT Agencies	
		Main characteristics	**Secondary characteristics**	**No.**	**Name**
4	Rural Areas	- Within rural areas only - Operates a fixed route (non-DRT) service - Door-to-door service available in some areas - Variable days and hours of operation by region	- Some agencies offer partial urban coverage for medical purposes only - Old fleet (more than 7.5 years on average)	6	CARTS
				13	Concho Valley Transit District
				14	Del Rio, City of
				15	ETCOG
				35	STAR Transit
				36	Texoma Area Paratransit System, Inc.
5	Non-Medicaid	- No service for the Medicaid market - Flexible route type or route deviation - Door-to-door service not available in most areas	- Partial coverage in most urban areas - No service on Sundays, some agencies operate on Saturdays - Buses are not common	2	ATCOG
				4	BCAA
				10	Colorado Valley Transit
				11	CACST
				20	Gulf Coast Center
				21	HOTCOG
				24	Lower Rio Grande Valley Development Council
				31	SETRPC
				38	Webb County Community Action Agency

1.3.1 Category 1: Small Areas

- **Agencies**: City of Cleburne, CCART, Fort Bend County Rural Transit District, Galveston County Transit District, SCRPT, SPAN, and The Transit System, Inc. (Figure 1.2)

- **Main characteristics**
  - Agencies in Category 1 serve an area smaller than 1,000 sq. miles; in fact, the largest agency in terms of area served (SPAN) covers only 878 sq. miles.
  - The agencies offer full coverage in urban areas, which may be a result of serving small areas.
  - All agencies operate using flexible routes. Additionally, Fort Bend County Rural Transit District operates with route deviation in some areas. No agency operates fixed DRT routes.

- **Secondary characteristics**
  - Fleets with buses are more common in this category than in other categories.
  - The fleet is young (less than 6 years on average) and small (less than 30 vehicles on average), compared to fleets in other categories.

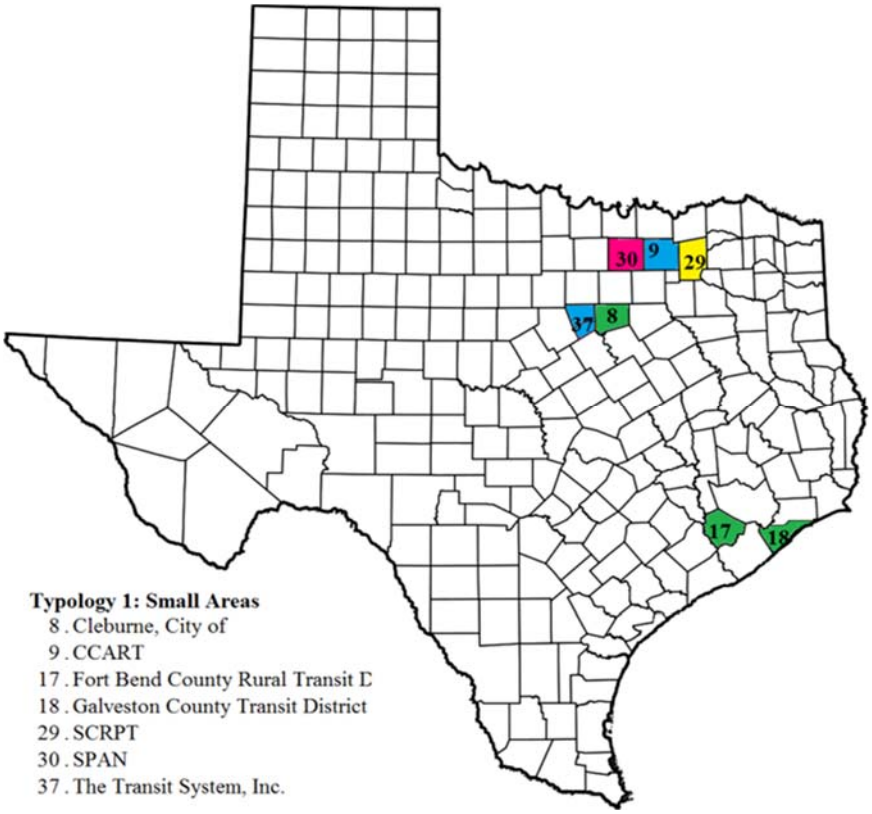


Figure 1.2: Agencies in Category 1

1.3.2 Category 2: Medium Areas

- **Agencies:** GCRPC, Kleberg County Human Services, Public Transit Services, RPMC, and REAL (Figure 1.3)

- **Main characteristics**
  - Agencies in Category 2 serve areas between 1,000 sq. miles and 8,000 sq. miles. The smallest agency in terms of spatial coverage (RPMC) serves an area of 2,340 sq. miles, while the largest (Kleberg County Human Services) serves an area of 6,583 sq. miles.
  - All agencies offer full coverage in urban areas.
  - Agencies operate using both flexible routes and route deviation, but do not operate fixed DRT routes.

- **Secondary characteristics**
  - Compared to agencies in other categories, the service starts operating relatively late (8:00 a.m. in most cases).
  - These agencies don't offer weekend service, except GCRPC, which operates from 8:00 a.m. to 5:00 p.m. during weekends for job access routes only (no DRT).

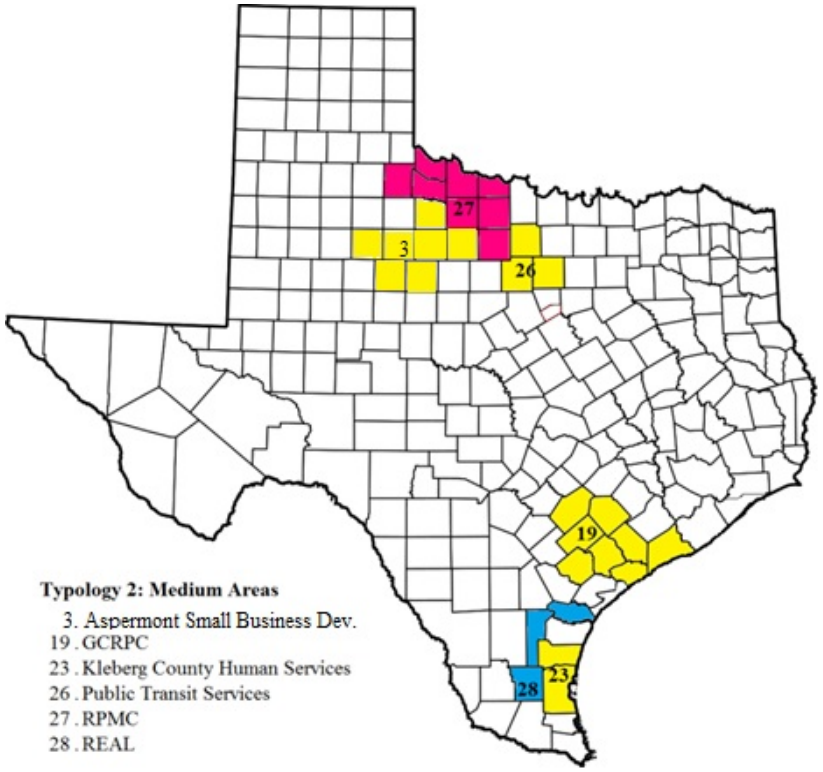


Figure 1.3: Agencies in Category 2

1.3.3 Category 3: Large Areas

- **Agencies:** AACOG, Brazos Transit District, Central Texas Rural Transit District, Hill Country Transit District, PCS, SPCAA, Southwest Area Regional Transit District, and WTO (Figure 1.4)

- **Main characteristics**
  - Agencies in Category 3 serve areas larger than 8,000 sq. miles. The smallest agency in terms of spatial coverage (Hill Country Transit District) serves an area of 8,415 sq. miles.
  - Agencies operate using both flexible routes and route deviation, but do not operate fixed DRT routes regularly (the exception is Hill Country Transit District, which works with fixed routes only in urban areas).

- **Secondary characteristics**
  - No service is offered on Sundays. Some agencies operate on Saturdays (Hill Country Transit District, SPCAA, and Southwest Area Regional Transit District).
  - The fleet is large (about 90 vehicles on average), compared to fleets in other categories.

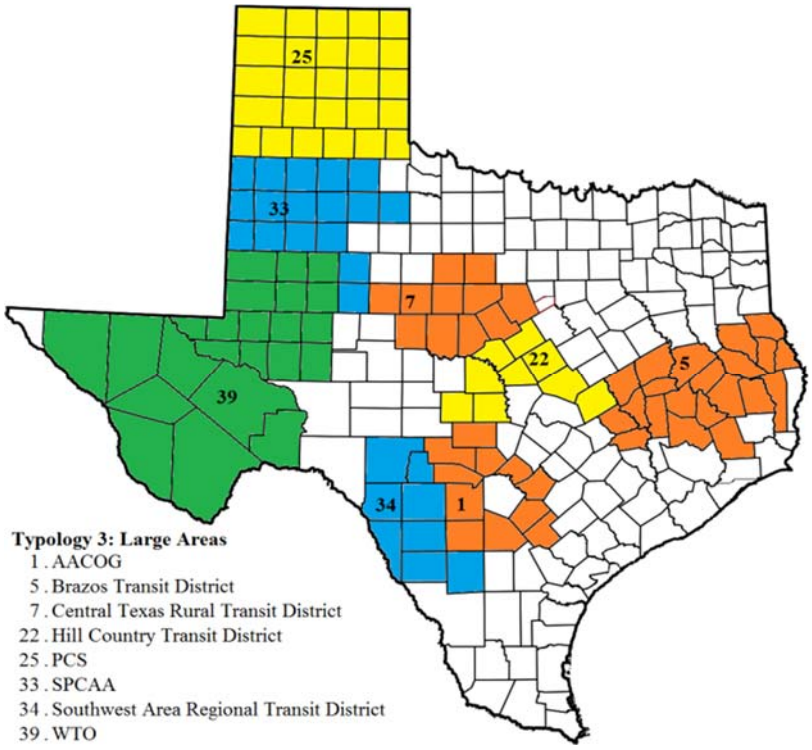


Figure 1.4: Agencies in Category 3

1.3.4 Category 4: Rural Areas

- **Agencies:** CARTS, Concho Valley Transit District, City of Del Rio, ETCOG, South Padre Island, STAR Transit, and Texoma Area Paratransit System, Inc. (Figure 1.5)

- **Main characteristics**
  - Agencies in Category 4 operate only in rural areas. Some agencies offer partial coverage in urban areas for medical purposes.
  - These agencies operate fixed routes parallel to DRT services, allowing them to connect rural and urban services.
  - Door-to-door services are available in several areas.
  - For most agencies, hours and days of operation vary by location and/or trip purposes.

- **Secondary characteristics**
  - Medical services (general medical assistance and Medicaid markets) are not available from some of these agencies. However, two agencies (CARTS and Concho Valley Transit District) offer free Medicaid services and, as mentioned, some agencies offer partial coverage in urban areas for medical purposes.
  - The fleet is old (about 7.5 years on average) compared to fleets in other categories.

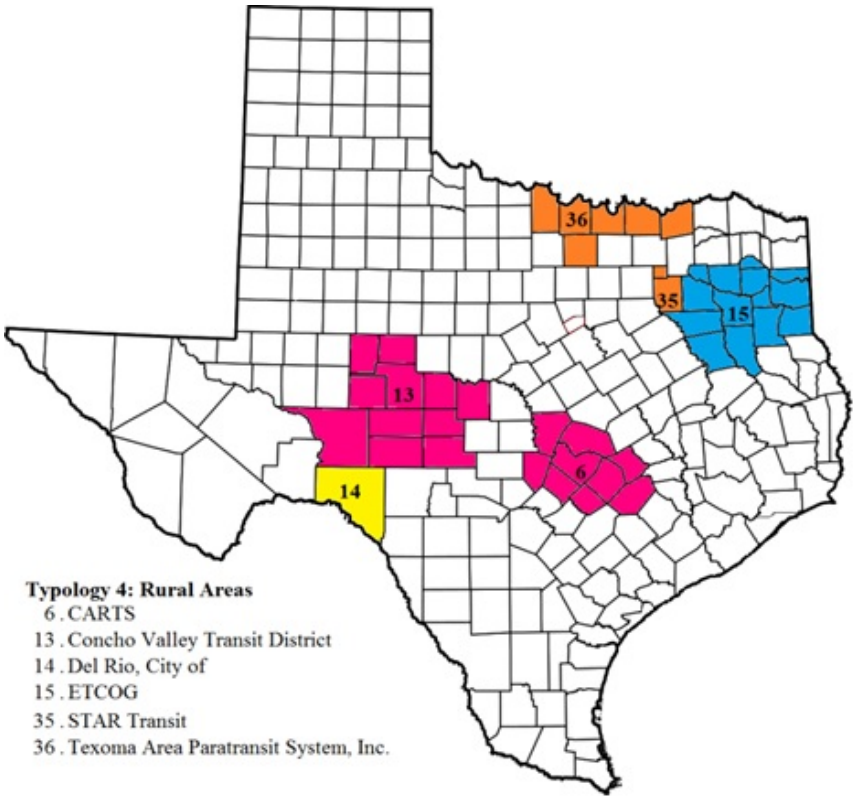


Figure 1.5: Agencies in Category 4

1.3.5 Category 5: Non-Medicaid

- **Agencies:** ATCOG, Aspermont Small Business Development Center, BCAA, Colorado Valley Transit, CACST, Gulf Coast Center, HOTCOG, Lower Rio Grande Valley Development Council, SETRPC, and Webb County Community Action Agency (Figure 1.6)

- **Main characteristics**
  - No service is provided for the Medicaid market.
  - Agencies operate using both flexible routes and route deviation, but do not operate fixed DRT routes.
  - Door-to-door service is not available, except for CACST.

- **Secondary characteristics**
  - Most agencies have partial coverage in urban areas. Exceptions are ATCOG and HOTCOG, which operate in rural areas only, and SETRPC and Webb County Community Action Agency, which have full coverage in urban areas.
  - No service runs on Sundays. Some agencies operate on Saturdays (ATCOG, Aspermont Small Business Development Center, and Lower Rio Grande Valley Development Council).
  - Fleets with buses are not common in the non-Medicaid category as compared to fleets in other categories.

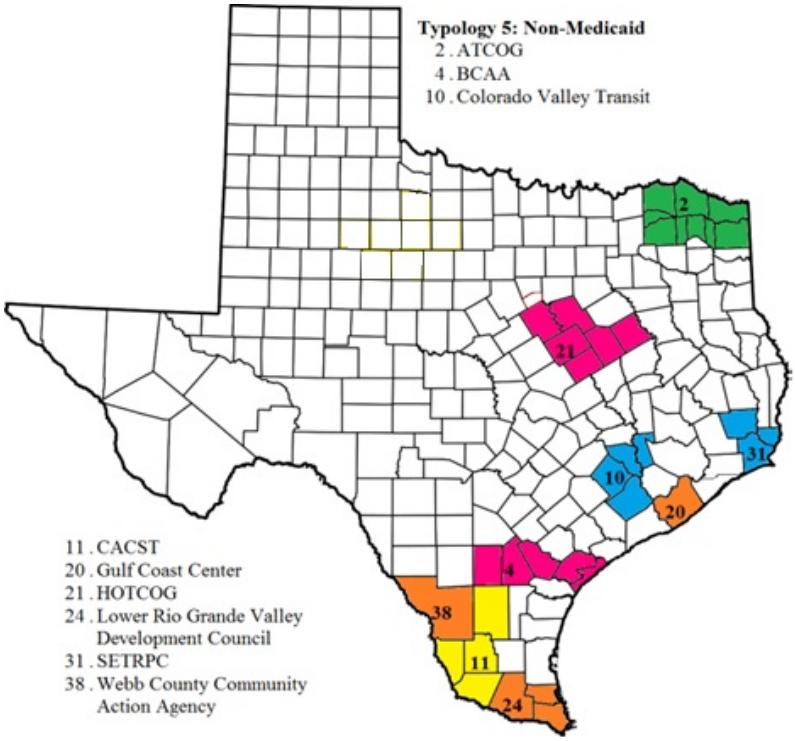


Figure 1.6: Agencies in Category 5

1.4 Discussion and Next Steps

The five categories defined in this chapter were based on a detailed analysis of the DRT dimensions presented in Table 1.3. The typology was developed in a recursive fashion, grouping agencies that shared common dimensions. Once the agencies were grouped, the team checked for common characteristics and re-classified agencies that did not fit into the assigned classification. This process was repeated several times, until a consistent classification for all agencies was found.

We would like to remark that the first three categories (Small Areas, Medium Areas, and Large Areas) were not defined arbitrarily, but based on the selection process described above. The agencies classified in each of these categories not only share similar coverage areas in terms of size, but also operate in similar ways (mainly in terms of spatial coverage and route type). These similarities may have arisen because of the area size.

A number of agencies could belong to more than one category. The team decided, based on each DRT service dimension, which category provided the best fit. For example, ATCOG (agency No. 2) was classified in Category 5—Non-Medicaid because the agency (1) does not serve the Medicaid market, (2) operates a flexible route type, and (3) does not offer door-to-door service. However, ATCOG also operates within rural areas only, which may qualify it to be classified in Category 4—Rural Areas. We decided to classify it in Category 5 because the agency has the three main characteristics of the category, though Category 4 could have been used too. The next chapter discusses the process taken to identify the prototypical agency for each category.

Chapter 2. Identifying Prototypical Agencies

2.1 Prototypical Agencies

As discussed in the previous section, the research team identified salient DRT service dimensions that, when taken together, comprehensively characterize DRT service. Based on these dimensions, the researchers developed a typology of DRT services and their operational/planning contexts, classifying the 39 DRT service providers into the following five distinct categories:

- Category 1: Small Areas
- Category 2: Medium Areas
- Category 3: Large Areas
- Category 4: Rural Areas
- Category 5: Non-Medicaid

Using the typology developed in Chapter 1, one transit agency was identified from each category as the prototypical agency in that category. The prototypical agencies selected from each category are (1) Fort Bend County Rural Transit District, (2) Public Transit Services, (3) Hill Country Transit District, (4) City of Del Rio, and (5) BCAA. Table 2.1 provides the characteristics of the five agencies by category. Figure 2.1 presents the coverage area of the prototypical agencies. The intent is that the DRT Accessibility Tool will be customized to these prototypical agencies within each category, and then may be used by other agencies in the category after modifications to fleet characteristics and demographic characteristics.

Table 2.1: Prototypical agencies by category

Category No.	Category label	Category characterization		Prototypical rural transit district agency
		Main characteristics	Secondary characteristics	
1	Small Areas	- Area served < 1,000 sq. miles - Full coverage in most urban areas - Flexible route type in most areas	- Buses are more commonly used than in other typology categories - Young fleet (less than 6 years on average) - Small fleet (less than 30 vehicles on average)	Fort Bend County Rural Transit District (Fort Bend)
2	Medium Areas	- Area served between 1,000 and 8,000 sq. miles - Full coverage in most urban areas - Flexible route type and route deviation	- Relatively late (8am) opening time - No service during weekends in most areas - Small vehicle capacity (12 seats per vehicle on average)	Public Transit Services
3	Large Areas	- Area served > 8,000 sq. miles - Flexible route type in most areas	- No service on Sundays, some agencies operate on Saturdays - Large fleet (more than 85 vehicles on average)	Hill Country Transit District (Hill Country)
4	Rural Areas	- Within rural areas only - Limited medical services provided - Operates a fixed route (non-DRT) service - Door-to-door service available in some areas - Variable days and hours of operation	- Some agencies offer partial urban coverage for medical purposes only - Old fleet (more than 7.5 years on average)	City of Del Rio (Del Rio)
5	Non-Medicaid	- No service for Medicaid appointments - Flexible route type or route deviation - Door-to-door service not available in most areas	- Partial coverage in most urban areas - No service on Sundays, some agencies operate on Saturdays - Buses are not common	Bee Community Action Agency (BCAA)

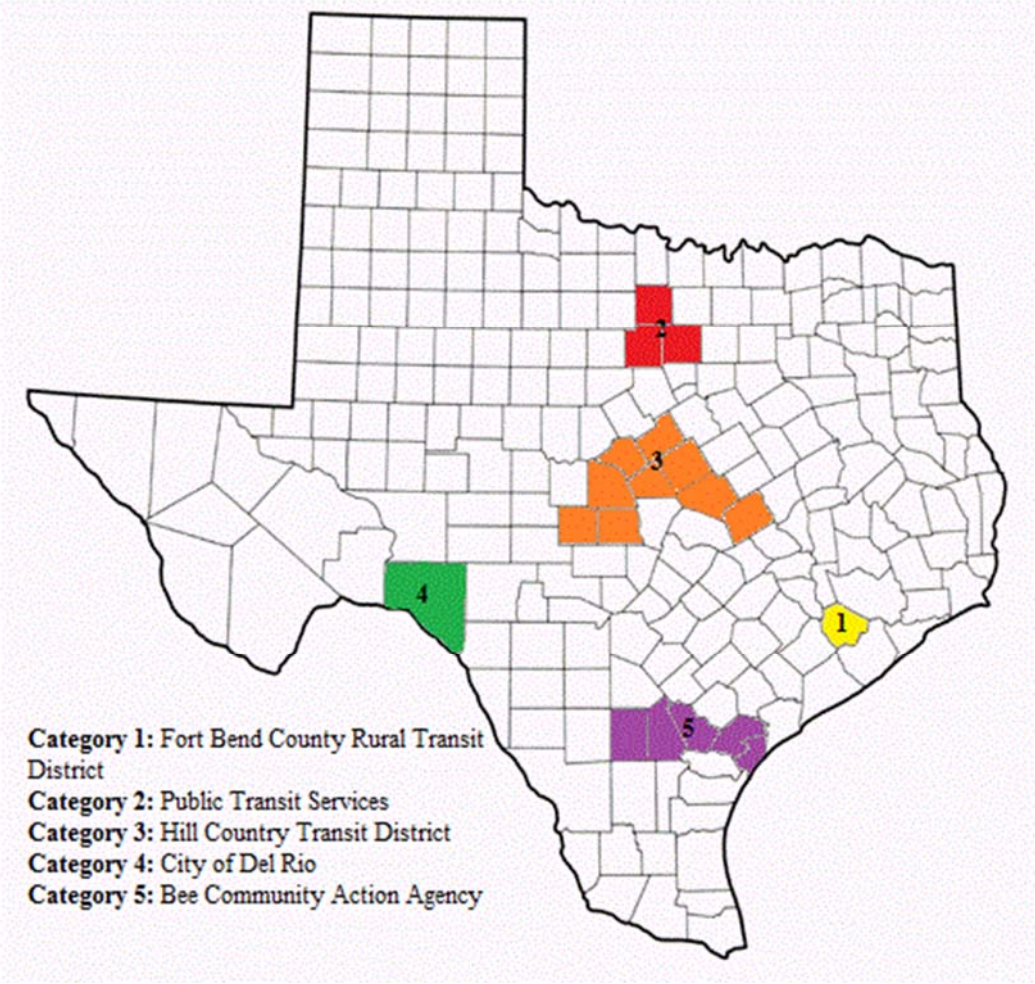


Figure 2.1: Coverage area of prototypical agencies

The next chapter will discuss how the CTR team contacted (via the phone or in person) each of the selected service providers to determine (a) the level of interest in developing DRT accessibility resources, (b) goals for applications of developing DRT accessibility resources, (c) staff's level experience with geographic information systems (GIS) and Microsoft Access, and (d) existing data and its sources. A careful evaluation of the feasibility of using each selected prototypical agency for developing the DRT tool was then made, based on the extent and form of data availability, interest levels, and need in the area. The prototypical agency selection was then confirmed or another agency was selected to serve as the representative agency.

Once the selection of prototypical agencies was completed and the availability of patronage data with the agencies verified, the research team moved on to the task of obtaining patronage data and other service area characteristics from the prototypical agencies.

Chapter 3. Obtaining Patronage Data from Prototypical Agencies

3.1 Data Required to Develop the DRT Accessibility Tool

The current DRT Accessibility Tool was developed based on patron and trip data from the DRT system operating in Brownsville, Texas. Brownsville is located within Cameron County at the southern tip of Texas and borders Mexico. The DRT Accessibility Tool uses a system of models to simulate actual daily DRT travel patterns for service regions and fleets of any size. Then, the tool can be used to determine how well a DRT system serves its riders and the most efficient ways to improve the service.

The data needed to develop DRT Accessibility Tools for the prototypical agencies can be classified into four categories:

- **Demographic data:** demographic characteristics of the area served by the agency, such as population, age, and household size.
- **Land use data:** corresponds to the area dedicated to different economic activities, such as retail, manufacturing, and residential
- **Vehicle fleet data:** includes information about all the vehicles operated by the agency.
- **Demand data:** for each trip made during the last year, the demand data includes information regarding date, origin and destination, and passenger characteristics.

Demographic data and land use data is required for each analysis zone in the agency coverage area. The analysis zone selected for the purpose of this research is census tracts. A detailed list of the data required is presented in Tables 3.1 to 3.4.

Table 3.1: Demographic data required to develop the DRT Accessibility Tool

Demographic data (at the census tract level)
Total number of households living within the zone
Total number of people living within the zone (population)
Area of zone, in square miles
Population density of zone, in number of people/square mile
Distance from zone centroid to nearest DRT transit line
Median age of the total population within the zone
Median age of men within the zone
Median age of women within the zone
Average household size within the zone
Total number of households that rent within the zone
Total number of households that are married with children within the zone
Total number of households that are married without children within the zone
Total number of people living in zone aged 18–29
Total number of people living in zone aged 30–49
Total number of people living in zone aged 50–64
Total number of people living in zone aged 65 or older

Table 3.2: Land use data required to develop the DRT Accessibility Tool

Land use data (at the census tract level)
Percent of area within the zone designated for apartments
Percent of area within the zone designated for commercial (including public buildings and space)
Percent of area within the zone designated for retail
Percent of area within the zone designated for manufacturing (including industrial)
Percent of area within the zone designated for residential
Distance between origin and destination zones, in miles

Table 3.3: Vehicle fleet data required to develop the DRT Accessibility Tool

Vehicle fleet data (for each vehicle in the fleet)
Maximum number of passengers the vehicle can hold
Number of days the vehicle is available on an average month
Number of patrons the vehicle can typically serve in an hour
Daily cost of vehicle operation, in dollars
Daily revenue of vehicle operation, in dollars
Number of hours vehicle is in service each day
Whether or not the vehicle is able to support mobility-impaired patrons
Vehicle age, in years

Table 3.4: Demand data required to develop the DRT Accessibility Tool

Demand data (for each trip over the last year)
Date (month/day/year)
Origin zone for pick-up
Desired destination zone
Scheduled pick-up time of the first leg (from home to destination)
Actual pick-up time of the first leg (from home to destination)
Scheduled arrival time of the first leg (from home to destination)
Actual arrival time of the first leg (from home to destination)
Scheduled pick-up time of the second leg (return trip)
Actual pick-up time of the second leg (return trip)
Scheduled arrival time of the second leg (return trip)
Actual arrival time of the second leg (return trip)
Passenger's gender
Whether or not the passenger is mobility-impaired
Purpose (church/meeting, education/school, seeking recreation, medical/therapy, shopping and work)

3.2 Data Collection Process

The data collection process was conducted from March to August 2013, and it consisted of three efforts: participation agreement, demographic and land use data collection, and fleet and demand data collection.

3.2.1 Participation Agreement

The first step after identifying the prototypical agencies was to contact the selected service providers to determine

1. the level of interest in developing DRT accessibility resources,
2. goals for applications of developing DRT accessibility resources, and
3. existing data and its sources.

Before the research team contacted the agencies, a TxDOT staff member emailed the agencies announcing our upcoming phone call. This email highlighted the main characteristics of this research effort and that participation in the project is optional. After this, we contacted each agency by phone to request their participation and to confirm data availability. Appendix C relays the contact information of the agencies' personnel that collaborated in this project.

All the prototypical agencies selected in Chapter 2 agreed to participate in the research project and confirmed that they would provide the data needed to develop the DRT Accessibility Tool. After this phone call, a confirmation email was sent to explain the following steps.

3.2.2 Demographic and Land Use Data

Demographic and land use data was obtained from data sources available online—no involvement from the rural transit district (RTD) agencies was needed.

Demographic data was found in the U.S. Census website for the latest year available (2010). The research team used the 2010 Census block group summary file SF1 demographic data, which are available to download at http://www.esri.com/data/esri_data/census2010.html. The researchers used ArcGIS maps combining U.S. 2010 Census maps and the TIGER county census tracts to mine all relevant data. After retrieving the data and compiling spreadsheets, the data requirements presented in Table 3.1 were obtained. Appendix D presents a short summary of the results for each of the five agencies.

Land use data was obtained from the National Oceanic and Atmospheric Administration's Coastal Assessment and Data Synthesis System[3]. The land use data consists of 39 land uses and was developed by the U.S. Geological Survey from the middle 1970s to the early 1980s. Then, the data was improved and updated by Texas A&M University using 1990 Census information to enhance the characterization of urban areas to better reflect the current conditions. The data is available at the county level and it was disaggregated into census tracts based on area-based proportions.

3.2.3 Fleet and Demand Data Collection

Fleet data was obtained from two sources: TxDOT and the agencies.

- TxDOT provided a spreadsheet with a consolidated active fleet inventory for the five prototypical RTDs. For each vehicle in the fleet, the spreadsheet includes information on mileage, age, price, model, fuel type, and vehicle condition.
- The agencies released information about daily cost of operation and daily revenue.

Demand data, on the other hand, was directly provided by the agencies. The RTD agencies were the only ones positioned to provide demand data at the level of detail required for the project. Some agencies supplied the demand data by email, while others provided paper copies (members of the research team visited the agency and gathered the required data). The data was received in different formats and for different time periods, and post-processing was required to use this information for modeling purposes.

For both the fleet and demand data, the research team assisted the RTD agencies in two ways to ensure that communications related to data requests were streamlined and efficient from the standpoint of the agency. First, the team generated a list of the specific datasets needed from the prototypical agencies, including desired file types and any required details, which each rural transit provider could use as a checklist. Second, the fleet and demand data from the RTD

[3] That data is available at http://coastalsocioeconomics.noaa.gov/coastalgeospatial/welcome.html

agencies was accepted in any electronic format (ASCII, SPSS, SAS, Excel, or other file types). The team offered assistance and support to the rural transit providers throughout this task. Consequently, the rural transit providers provided the data faster because they did not need to be concerned about consistency or presentation of the data from multiple sources.

The next chapter discusses the data assembly process. This task involved, in part, assembling the demand data in a form suitable for the suite of behavioral demand models characterizing DRT travel. For this purpose, the demand data from each prototypical RTD agency was translated into trip origin-destination records identified with the zones in the region. Appropriate data cleaning and screening was undertaken to ensure data consistency and quality, followed by the development of explanatory variables for each trip record that retains information on individual characteristics.

Chapter 4. Assembling Data for Estimation and Application

4.1 Data Needs to Develop the DRT Accessibility Tool

The current DRT Accessibility Tool was developed based on patron and trip data from the DRT system operating in Brownsville, Texas. Brownsville is located within Cameron County at the southern tip of Texas and borders Mexico. The DRT Accessibility Tool uses a system of models to simulate actual daily DRT travel patterns for service regions and fleets of any size. Then, the tool can be used to determine how well a DRT system serves its riders and the most efficient ways to improve the service.

The DRT Accessibility Tool uses a series of probability models, linear models, and discrete choice models to simulate DRT patron characteristics and decisions. A brief description of all the models involved in the DRT Accessibility Tool can be found in Appendix E, including a detailed list of the variables considered in each of the models. The data needed to develop the DRT Accessibility Tool for the prototypical agencies can be classified into four categories:

- **Demographic data:** demographic characteristics of the area served by the agency, such as population, age distribution, and household size distribution.
- **Land use data:** corresponds to the area dedicated to different economic activities, such as retail, manufacturing, and residential.
- **Vehicle fleet data:** includes information about all the vehicles operated by the agency.
- **Demand data:** for each trip made during the last year, the demand data includes information regarding date, origin and destination, and passenger characteristics.

Demographic data and land use data are needed for each analysis zone in the agency coverage area. The spatial unit for analysis zones selected for the purpose of this research is the census tract. A detailed list of the data needed for each of the four data types identified above was provided in Tables 3.1 through 3.4.

4.2 Assembly of Data

The data collection process was conducted from March to August 2013, and it consisted of two efforts: demographic and land use data collection, and fleet and demand data collection. Demographic and land use data were obtained from data sources available online (no involvement from the RTD agencies was needed). Fleet data was obtained from two sources: TxDOT and the RTD agencies. Demand data was directly provided by the agencies. The data was received in different

formats and for different time periods, and post-processing was required to use this information for modeling purposes. As result, the research team compiled the information for each agency in three different files: a spatial GIS data of the area of service, a spreadsheet with the vehicle fleet data, and a spreadsheet with the demand manifest of one entire year. The following sections describe how the research team assembled each of the data files in a suitable form for estimation.

4.2.1 Spatial GIS Data

Spatial GIS data was collected in the form of two main shapefiles, or digital map features, for roads and census tracts. A number of steps were used to format and clean the shapefiles: first, the shapefiles were formatted and clipped to the area within the service region of each DRT agency (an area typically defined by the counties served by each agency). Second, sociodemographic data for each census tract was added from the census summary file SF1 demographic library. Third, land uses for each census tract were added in the form of zoning. The land use categories included manufacturing, commercial, retail, apartments, and general residential. The land use data is available at the county level and it was disaggregated into census tracts based on area-based proportions. Fourth, distances between every pair of census tract centroids were calculated.

4.2.2 Vehicle Fleet Data

TxDOT provided a spreadsheet with a consolidated active fleet inventory for the five prototypical RTDs. For each vehicle in the fleet, the spreadsheet includes information on mileage, age, price, model, fuel type, and vehicle condition. One of the agencies (BCAA) released information about the daily cost of operation and daily revenue. For the rest of the RTDs, the daily cost of operation and daily revenue were obtained from the annual cost and revenue reported in the National Transit Database, dividing the annual total by the number of days the agency was operating during the year and the average number of vehicles available. Except for this conversion from annual to monthly cost/revenue, the rest of the fleet characteristics were ready to serve as input for the models.

4.2.3 Demand Manifest

The demand manifest contains the DRT patron trips. The information, in general, is available in one spreadsheet and contains the address of the origin and destination, passenger gender, whether the passenger is mobility-impaired, trip purpose, date of the trip, actual pick-up time, actual drop-off time, scheduled pick-up time, and scheduled drop-off time.

The demand manifest data is needed to estimate the parameters of the behavioral models embedded in the DRT tool. As was identified in Table 3.4, the ideal data for our needs is the demand manifest data over the period of a year (to include seasonality effects), as well as all the elements listed in the table. The research team had the most difficulty in obtaining this data. Table 4.1 provides the status of the data elements in our possession from each RTD. The research team

developed the DRT tool for each of the five prototypical agencies, although the behavioral parameters for some demand components (or for the entire demand system in the case of Public Transit Services) were borrowed from the estimated models for other similar agencies.

Table 4.1: Status of the collected demand data

Demand data (for each trip over the last year)	Fort Bend	Public Transit Services	Hill Country	Del Rio	BCAA
Date (month/day/year)	✓	×	✓	✓	✓
Origin zone for pick-up	×	×	✓	✓	✓
Desired destination zone	×	×	✓	✓	✓
Scheduled pick-up time of the onward trip (from home to destination)	✓	×	✓	✓	✓
Actual pick-up time of the onward trip (from home to destination)	✓	×	✓	✓	×
Scheduled arrival time of the onward trip (from home to destination)	×	×	✓	✓	✓
Actual arrival time of the onward trip (from home to destination)	✓	×	✓	✓	×
Scheduled pick-up time of the return trip	✓	×	✓	✓	✓
Actual pick-up time of the return trip	✓	×	✓	✓	×
Scheduled arrival time of the return trip	×	×	✓	✓	✓
Actual arrival time of the return trip	✓	×	✓	✓	×
Passenger's gender	✓	×	×	✓	✓
Whether or not the passenger is mobility-impaired	✓	×	✓	✓	✓
Purpose (church/meeting, education/school, seeking recreation, medical/therapy, shopping and work)	✓	×	✓	✓	✓

✓: Data collected ×: Data not collected

4.2.4 Merging Spatial GIS Data and Trips

The spatial GIS and patronage trip data were combined. In this last step, origins and destinations were geocoded (plotted on the map) in ArcGIS. By merging these files, the research team was able to graphically depict trip origins and destinations. The resulting file corresponds to trip origin-destination records identified by the zones (census tracts) in the region. Finally, the zone characteristics of the origin and destination of each trip were appended to the patronage data. The resulting file corresponds to a detailed demand manifest, in a trip origin-destination format, with a complete description, in terms of sociodemographics, of the census

tract where the origin and destination are located. This final file is in a form suitable for estimation by the suite of behavioral demand models characterizing DRT travel. The entire merging process is explained in detail in Appendix F.

4.3 Discussion and Next Steps

This chapter documented the process for assembling the needed data in a suitable format. The next chapter describes the use of the prepared data to estimate the behavioral models of DRT demand. The estimated models have many additional variables compared to the current models of DRT demand. Specifically, fleet characteristics data is also considered as explanatory variables in the total patron demand model, to examine whether improving fleet characteristics has the effect of driving up DRT patron demand. In addition to models of demand, the research group also estimated patron scheduling models for the four service characteristics (in-vehicle times, arrival time delay, pick-up time uncertainty, and unmet demand), using the patron level data from each prototypical agency and the corresponding service area and fleet characteristics.

Chapter 5. Estimating Agency-Specific Models

5.1 Models of DRT Demand and Patron Scheduling

The DRT Accessibility Tool runs a simulation that uses multiple models and statistical information from the prototypical DRT agency to generate patron demand, complete with trip purpose, time of day, and other features, which then are evaluated to determine how well service meets the demands. Nine models are involved in the simulation:

1) *Total Patron Demand Generation:* This linear regression generates patron demand from each area[4] of DRT service. Actual DRT demand logs from the prototypical agencies have been correlated with numerous traits of the area, as provided by the 2010 Census, including the population size of the census tract, the average household size in the census tract, the percentage of the census tract households who rent, and the percentage of tract population of a certain age bracket.

2) *Trip Purpose Estimation:* This multinomial logit (MNL) model[5] assigns a trip purpose to each patron, based upon their gender, mobility, and age (if available). Recorded trip purposes vary slightly between prototypical agencies, but medical, work, social and recreational, education, and shopping were common purposes among the agencies. A detailed description of the purpose classification of each agency can be found in the next section.

3) *Destination Zone Assignment:* The destination of each passenger may then be assigned through this MNL model. The model considers the characteristics of each available destination area, including the population density, and the percentage of the area zoned for apartments, commercial, retail, and manufacturing. The passenger's trip purpose, gender, age, and mobility are also considered.

4) *Time-of-Day Allocation:* A DRT user may in general choose to leave in the morning, and may then return in the morning or the afternoon, or may choose to leave in the afternoon. As the vast majority of the trips served by DRT are single-day trips, without an overnight stay anywhere, trips that involve leaving on one day and returning on another are not considered in the DRT. The variables considered in this model are trip purpose, the

[4] The service region could be divided into any type of geographic area unit, such as census block group, census tracts, census block, traffic analysis zones, etc.

[5] MNL discrete choice models predict the utility (level of satisfaction) associated with various alternatives. The assumption here is that individuals are most likely to choose the alternative that provides them the largest satisfaction (utility). In this case, the different alternatives are the different purposes.

distance between the centroid of origin and destination areas, and the mobility of the passenger.

5) *In-Vehicle Travel Time:* This model generates a number for the length of travel time each individual spends in the DRT vehicle. The model is based on research by Schofer et al. (2003). The National Household Travel Survey (NHTS) provides a classification of an area's level of urbanization. Using this classification, the distance between the origin and destination can be translated into an expected in-vehicle travel time, accounting for the traffic typical in such urbanized (or rural) areas. This figure is calculated for both the origin and destination's urbanization levels, and the longer of the two is accepted. For trips that begin and end in the same area, a minimum travel distance is assumed. Schofer et al.'s model was based upon national data. As we used the most recent NHTS urbanization index in our estimation of this model, we do not require modification of this model for the agencies in Texas.

6) *Drive-Alone Equivalent Time:* This linear regression model estimates how long it would take a DRT user to complete their journey if they were able to use a private vehicle for their trip. The straight-line distance between area centroid pairs is known and is correlated with the shortest path travel distances on existing roads between area centroid pairs, as determined from GIS data. An average travel speed of 30 mph was assumed to determine travel time.

7) *Pick-Up Time Uncertainty:* This log-linear regression model estimates the minutes of uncertainty a patron faces in ride pick-up time, calculated as the absolute value of expected pick-up time minus actual pick-up time. The model uses trip purpose, mobility, time of day, and season of the year to establish the expected uncertainty.

8) *Arrival Time Delay:* Arriving late at a destination is not ideal, and may be discouraging to potential and current DRT riders. Lateness is especially problematic for work or appointments, but can also impact shopping trips, as arriving late can shorten the time available to obtain required items before the return pick-up. The length of delay (in minutes) in arriving at a destination is therefore modeled as a log-linear regression, based upon the time of day, season of year, mobility, and passenger gender. Early arrival and on-time arrival are both treated as having zero arrival delay.

9) *Accessibility Index:* This final model determines how accessible patrons find their DRT service, based upon the simulated service characteristics. The weighting of the service characteristics was determined from the importance given to each by the actual DRT patrons of each prototypical agency, which were collected in a survey in January and February 2014.

In the next section the estimation results are presented. As previously discussed, the in-vehicle travel time model (number 5) does not require re-estimation for each agency. The weights in the accessibility index (number 9) were obtained for each agency after the surveys were completed.

5.2 Estimation Process and Main Results

During the data collection, the research group faced several issues regarding the availability of data. The limitations are summarized here:

- We were unable to obtain the actual drop-off and pick-up times for the BCAA. The agency records this data only on paper and they did not give us the permission to pick up the hard copies and bring them to Austin (to digitize the information).
- Del Rio's demand data was also recorded only on paper. We had access to the demand manifest and, of course, post-processing was required to use this information for modeling purposes. Due to the excessive amount of time required to translate the paper information to a digital file (an Excel spreadsheet), the demand data for only one month (February 2012) was translated.
- Because Hill Country and Fort Bend do not collect the gender of their passengers, the research team estimated models without the gender segmentation for these agencies.
- Public Transit Services did not provide us any demand manifest data. They stated that they lacked the necessary resources to cooperate with our data request.
- The only two agencies that schedule a preferred drop-off time are Del Rio and BCAA. Since we did not have access to the actual drop-off time records of BCAA, the arrival time delay model was fed only Del Rio data.
- Travel time skims are needed to compute the drive-alone travel time. The only metropolitan planning organization (among those located in the coverage areas of the four agencies) with travel skims available is the Houston-Galveston Area Council, allowing the estimation of the drive-alone travel time model for Fort Bend.

Despite those limitations, the research team developed the DRT tool for each of the five prototypical agencies, although the behavioral parameters for some demand components (or for the entire demand system in the case of Public Transit Services) were borrowed from the estimated models for other, similar agencies.

For all the agencies, some common assumptions and definitions were established:

- The qualifications of a mobility impairment, as used in these models, includes any one or combination of the following: use of a wheelchair, use of a power scooter, use of a walker, use of crutches or a cane,

blindness, the need for a lift into the transit vehicle, the presence of a service animal, or other assistive medical devices, such as an oxygen tank. The trip logs indicate that about 20% of each agency's patrons are mobility-impaired.

- For certain agencies (Del Rio and BCAA), it is possible to model patron age group, such as youth under age 18, elderly patrons (over age 65), and adult (between 18 and 65).
- The geographic unit of analysis is the census tract for Fort Bend and Hill Country. For Del Rio and BCAA, a Census Block Group (CBG) level was used. Del Rio's area of coverage corresponds to Val Verde County, comprising only 9 census tracts or, equivalently, 34 CBGs. Since the number of observations in the estimation of the Patron Demand Generation and Destination Zone Assignment models corresponds to the number of geographic units, the census-tract-level option was discarded in order to obtain a sufficient number of observations and thus capture the richness and heterogeneity of the entire Val Verde County. Similarly, a 66-CBG subdivision was preferred over a set of 20 census tracts for BCAA's coverage area.
- The models assume that each trip consists of two legs: one from the home to the destination and the other one from the destination to the home. This assumption is consistent with most DRT trips (around of the 85% of the trips logged by the agencies were exactly two legs).
- Around 10% of the data was dropped due to missing information: no records of origin or destination address, missing drop-off or pick-up time, or no indication of the mobility impairment (if any) of the passenger.
- All the agencies defined their coverage area based on the counties they serve (see Figure 2.1). Fort Bend serves Fort Bend County; Hill Country serves Bell, Coryell, Hamilton, Lampasas, Llano, Mason, Milam, Mills, and San Saba Counties; Del Rio serves Val Verde County; and BCAA serves Aransas, Bee, Live Oak, McMullen, and Refugio Counties. The four agencies for which we have data allow some destinations outside their corresponding coverage area (trips to important cities like Austin, San Antonio, Houston, Dallas, etc.). Destinations within the coverage area are termed *interior* and destinations outside the coverage area are termed *exterior*. The number of trips to an exterior zone is huge in the BCAA data (90% of the trips); in contrast, only 1.8% of Hill Country trips have an external zone as destination. Del Rio and Fort Bend vary widely in terms of exterior trips as well, at 27% and 61% respectively.
- The classification of trip purpose varies among the agencies. Del Rio and Fort Bend share the same the same classification of four purposes: Education, Medical (includes any medical appointment, dialysis, pharmacy, etc.), Work, and Other (includes shopping, going to church, errands, and other activities). On the other hand, BCAA and Hill Country

have the same classification of five purposes: Education, Medical (includes any medical appointment, dialysis, pharmacy, etc.), Recreation (includes visiting relatives and any other recreation activity), Shopping, and Work. The most common trip purpose is Medical for patrons in Del Rio and Hill Country, in contrast to Fort Bend and BCAA, where the Medical purpose represents only around 12% of the trips. The most common trip purpose for BCAA's patrons is Education (57% of the trips), a purpose that represents 29% of the Fort Bend's patrons trips. The most common purpose in the Fort Bend's trip logs is Other (shopping, recreation, and other activities beside work, medical appointments, and education-related).

- The same land use classification is used four the four agencies, falling into four non-overlapping categories: Agricultural, Residential, Commercial and Services, and Industrial.
- All the selected variables in the specification of the models have to be easy to obtain for any DRT agency in Texas. The communication between the research group and the four agencies resulted in a realistic understanding of the kind of data the agencies can provide. Also, the sociodemographic variables can be easily obtained from the 2010 Census data. This concept of practical models, in which we rely on readily obtainable data, necessitates the use of simple variables—for example, the distance between the centroid of the origin zone and the destination zone, instead of the actual straight-line distance between origin and destination.
- As we mentioned before, trips that involve leaving on one day and returning on another are not considered in the models' estimation (around 1% of the trips were dropped due to this assumption). Travel out in the morning and return in the afternoon is the most common travel schedule for all the agencies, representing around 85% of the trips.
- All the models for Fort Bend, BCAA, and Hill Country were estimated using the demand logs for one entire year. As discussed earlier, Del Rio data consists of only one month.

Table 5.1 summarizes the models estimated and the variables included in the different formulations. The main results and conclusions are listed in the following sections.

Table 5.1: Summary of models and variables

Model Name	Model Type	Software	Variables involved (dependent variable in italic)	Del Rio	Fort Bend	BCAA	Hill Country
Total Patron Demand Generation	Linear Regression	SPSS	*Total number of patrons in each census zone*	✓	✓	✓	✓
			ln(Total population size within census zone)	Y	Y	Y	Y
			Average household size within census zone	Y			
			Percentage of census zone population Hispanic or Latino	Y	Y	Y	Y
			Percentage of census tract households that rent	Y	Y	Y	Y
			Percent of census tract population aged 50–64			Y	
			Percent of census tract population aged 65 or older	Y	Y	Y	Y
Trip Purpose Estimation	MNL	SPSS	*Trip purpose*	✓	✓	✓	✓
			Age segment (Youth, Adult, or Elderly)	Y		Y	
			Passenger gender	Y		Y	
			Whether or not the passenger is mobility-impaired	Y	Y	Y	Y
Destination Zone Assignment	MNL	GAUSS	*Destination zone of each trip*	✓	✓	✓	✓
			Total population of each census zone			Y	
			Distance between origin and destination census zone centroids (miles)	Y	Y	Y	
			Land use (percent of area zoned to Agricultural, Residential, Commercial and Services, and Industrial)	Y	Y	Y	Y
			Trip purpose	Y	Y	Y	Y
			Passenger gender			Y	
			Whether or not the passenger is mobility-impaired		Y		
Time of Day Allocation	MNL	GAUSS	*Time of day allocation for each trip (alternatives are travel out in the AM and return in the AM, travel out in the AM and return in the PM, travel out in the PM and return in the PM)*	✓	✓	✓	✓
			Distance between origin and destination census zone centroids (miles)		Y	Y	Y
			Trip purpose	Y	Y	Y	Y
			Age segment (Youth, Adult, or Elderly)	Y		Y	
			Passenger gender	Y		Y	
			Whether or not the passenger is mobility-impaired	Y	Y	Y	Y

Model Name	Model Type	Software	Variables involved (dependent variable in italic)	Del Rio	Fort Bend	BCAA	Hill Country
Drive Alone Equivalent Travel Time	Linear Regression	SPSS	*Drive alone equivalent travel time for each trip (minutes)*	×	✓	×	×
			Distance between origin and destination census zone centroids (miles)		Y		
Pick-up Time Uncertainty	Log-linear Regression	SPSS	*Difference in time between scheduled and actual pick-up for each trip (minutes)*	✓	✓	×	✓
			Time of day allocation for each trip		Y		
			Trip purpose	Y	Y		Y
			Season of the year when the trip is performed		Y		Y
			Age segment (Youth, Adult, or Elderly)	Y			
			Passenger gender	Y			
			Whether or not the passenger is mobility-impaired	Y	Y		Y
			Whether or not the destination zone is within the main coverage area		Y		Y
Arrival Time Delay	Log-linear Regression	SPSS	*Minutes late arriving at destination*	✓	×	×	×
			Time of day allocation for each trip	Y			
			Trip purpose	Y			
			Age segment (Youth, Adult, or Elderly)	Y			
			Whether or not the passenger is mobility-impaired	Y			
			Whether or not the destination zone is within the main coverage area	Y			

✓: Model was estimated ×: Model was not estimated Y: coefficient was estimate

5.2.1 Total Patron Demand Generation

Appendix G presents the results of the linear regression used to predict the total number of patrons requesting a DRT trip from each service area zone. These results indicate some shared trends among the four agencies. First, the demand seems to increase with the population (as expected). Second, zones with a greater percentage of population aged 65 or older tend to generate more DRT trips. Third, the demand increases with the percentage of households that rent within the zone. Finally, zones with a higher percentage of Hispanic (or Latino) population generate more DRT trips.

5.2.2 Trip Purpose Estimation

Appendices H.1 and H.2 provide the results for the trip purpose estimation for Del Rio and Fort Bend (four purpose classifications) and BCAA and Hill Country (five purpose classifications). Using these parameter values, the simulation will assign trip purposes based on gender, mobility, and age segment. For each purpose we can predict the utility and then, making a comparison between utilities (with the well-known logit form), we can compute the probability that a certain patron will perform a trip with a certain purpose. For example, for a mobile male adult using the Del Rio DRT system, the utility of Medical purpose will be $U_m = 2.367$; the utility of Work purpose will be $U_w = 4.299 - 1.457 = 2.842$; the utility of Other purpose will be $U_o = 2.268 - 0.491 = 1.777$; and finally the utility of Education purpose will be $U_e = 0$ (since Education is the base). Then the probability of this individual choosing Medical corresponds to $\exp(U_m)/(\exp(U_m) + \exp(U_w) + \exp(U_o) + \exp(U_e)) = 0.30$, meaning that for each 100 mobile male adults Del Rio patrons, approximately 30 of them will have Medical as trip purpose.

5.2.3 Destination Zone Assignment

The results of the MNL model used to predict where each DRT patron is most likely to travel is presented in Appendix I. The model will be applied later to calculate, for each of the patrons, the probability of choosing each census zone (a process similar to the trip purpose prediction explained in the previous section). Results show that DRT patrons prefer destinations that are closer to the origin, except for Hill Country where the effect of distance is not significant, probably because Hill Country's patrons only perform interior trips (as we mentioned earlier, 1.8% of trips have an exterior zone as destination) and long trips are uncommon. In general, patrons prefer destinations that are less populated, especially for BCAA's mobility-impaired patrons. Patrons are more likely to go to destinations zoned to support the kind of activity they are undertaking. For example, patrons with shopping trip purposes are most likely to visit zones with a greater amount of area dedicated to commercial and less likely to visit zones with greater amount of area dedicated to residential. As we can see in Hill Country's patrons, people traveling to work are most likely to visit zones with greater area dedicated to industrial enterprises, and apparently they avoid zones with a greater area dedicated

to residential. BCAA's patrons with the work trip purpose are most likely to travel to zones with greater area dedicated to communication and services. Medical is the only purpose with a significant effect on the destination selection for Del Rio's patrons, probably because most of the patrons have Medical as trip purpose.

5.2.4 Time of Day Allocation

The results of the MNL model used to simulate the decision of when to travel are presented in Appendix J. One common phenomenon appears in the three agencies where travel distance was a significant explanatory variable (Fort Bend, BCAA, and Hill Country): patrons are more likely to complete their travel during the morning if they travel smaller distances. A greater travel distance may inherently lengthen the time between departing the home and returning to the home. Also, performing activities with a mobility impairment likely takes longer than without, a supposition supported by the Fort Bend results: mobility-impaired patrons prefer to begin their travel in the morning and end it in the afternoon. Fort Bend patrons are more likely to schedule their medical appointments in order to finish them during the morning—exactly the opposite schedule they look for when they are scheduling their work. Del Rio patrons tend to end their medical appointments in the same period of the day they began (either morning or afternoon). Also, Del Rio male patrons tend to spread their travel across the entire day. The probabilities of choosing to travel during the three different time options are calculated for each patron and each agency using the results of this model in a process very similar to the one detailed in Section 5.2.2.

5.2.5 Drive-Alone Equivalent Travel Time

Appendix K shows the results of the linear regression used to estimate the drive-alone equivalent time in minutes for Fort Bend trips. Since the specification has only one variable, the full model is presented.

5.2.6 Pick-Up Time Uncertainty

The results of the log-linear regression that estimates the difference in minutes between the scheduled and actual pick-up times, regardless of whether it is early or late, are presented in Appendix L. We can see two common results between Fort Bend and Hill Country (the two largest of our study set, in terms of number of trips per year): first, mobility-impaired patrons tend to experience more uncertainty and, second, patrons traveling to external zones experience more time uncertainty. During the slowest seasons—summer and winter—Hill Country patrons experience lower time uncertainty. However, the winter season apparently increases time uncertainty for Fort Bend travelers. Those travelling for work also tend to experience less uncertainty in both areas. On the other hand, Del Rio patrons traveling for education purposes have less time uncertainty than those traveling for medical appointments, work, or other activities. Male Del Rio patrons have more uncertainty than female patrons and elderly passengers have less time uncertainty than do adults or young people.

5.2.7 Arrival Time Delay

Appendix M presents the results of the log-linear regression that estimates the number of minutes a patron will arrive late at their destination. The only agency that gave us open access to the scheduled drop-off time was Del Rio, so only one version of the model was estimated. We can see that Del Rio patrons starting their travel in the morning experience less delay than those starting their travel in the afternoon. Those traveling to medical appointments tend to experience more delay than those traveling for education, work, or other activities. It is interesting to note that mobility-impaired and elderly patrons have less delay, perhaps due to the extra time that the agency builds in to offer assistance in boarding. Finally, patrons traveling to zones outside the main coverage area tend to experience more delay than others, probably because for longer trips the travel time is more unpredictable.

5.3 Discussion and Next Steps

The aim of this project was to update the current models embedded in the DRT tool and make the tool specific to each category. Since we have an agency-specific version of most of the models, we were able to create different tools for each of the different agency categories. The current tool (the one constructed using the Brownsville's data) was substantially improved in several ways. All the demographics and related models were updated from Census 2000 to Census 2010 information. Additionally, specification of most of the models was redesigned and some variables not previously considered were added. The most important modifications were the presence of age in the models and the distinction between interior and exterior zones. Since most of the agencies operate in a pure DRT environment, one of the variables considered in the current tool, distance to the nearest DRT transit line, did not play a significant role in the behavioral models of the DRT operation. Despite that, all the models are statistically significant and their specifications explain, in a simple and consistent way, the different behaviors of the various categories of DRT agencies and patrons.

The next chapter describes the survey conducted to obtain the value that patrons assign to each of the service characteristics. With these values in hand we were able to update the Accessibility Index definition and the tool itself.

Chapter 6. Designing and Administering Survey

6.1 The Accessibility Index

The last model involved in the tool determines how accessible the patrons find their DRT service, based upon the simulated service characteristics. The accessibility is measured as the weighted sum of the relevant service characteristics. The weighting of the service characteristics was determined from the importance given to each by the actual DRT patrons of each prototypical agency, which were collected in a survey in February 2014. In this chapter, we report the design, administration, and analysis of the survey.

The level of accessibility experienced by patrons is calculated based on four relevant travel characteristics that describe how well each patron is being served by the DRT system. These travel characteristics were identified during the development of the existing Accessibility Tool, based on a survey of paratransit patrons in Tyler, Texas (see LaMondia and Bhat, 2010). They include the following four attributes:

a) Number of minutes late a patron arrives at her or his destination.

b) The time difference (in minutes) between when a patron was scheduled to be picked up and when he/she actually was picked up.

c) Difference in minutes between the time a patron spends in the DRT vehicle and the equivalent time it would have taken if he/she was able to drive a personal vehicle.

d) Percentage of the patrons who could not be scheduled during this period in the patron's originating zone.

The accessibility index, computed at the patron level, is obtained as the weighted sum of the above four characteristics. The specific values of the weights are obtained from a patron survey. Next, the accessibility measures at a patron level are averaged across patrons in each service area zone. Then the tool assigns to each zone a final accessibility index value representing minutes of delay, with lower values representing higher accessibility. The model formulation embedded in the existing tool can be found in Appendix N.

In the next section, we present the survey design process. Then we report how the survey was delivered to each agency and how the agencies conducted the survey. Finally, we analyze the results and specify the weights of the accessibility index.

6.2 The Survey

A well-designed questionnaire can help achieve the project goals efficiently and reliably. Earlier research indicates that certain attributes of a respondent have

an important impact on her or his valuation of service characteristics, including passenger age, passenger gender, and frequency of using the transit service. Hence, recording such information in our questionnaires is critical. In our survey, we recorded age information in four age groups: under 18 years old, 18 to 40 years old, 41 to 65 years old, and older than 65 years old. The frequency of transit use was obtained in five categories: every day, twice a week, once a week, once a month, and other.

For the question of how important the service characteristics are to the respondents—the most essential part of the survey—we used a Likert scale that captured perceptions on a five-point scale: "Not important," "Moderately unimportant," "Neutral," "Important," and "Very important." Because a significant number of target respondents in the service regions speak Spanish, we provided both English and Spanish versions of the survey questionnaires. Figures 6.1 and 6.2 present the English and Spanish versions, respectively, of the survey.

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Versión en español al reverso

Thank you for taking the time to complete this survey. Your feedback is important to us in how we can better improve transit service. This survey should only take about 5 minutes of your time and your answers will be completely anonymous.

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Other (Please Specify): _____

What is your age?

- ☐ Under 18 years old
- ☐ 18-40 years old
- ☐ 41-65 years old
- ☐ Older than 65 years

How often do you take this bus?

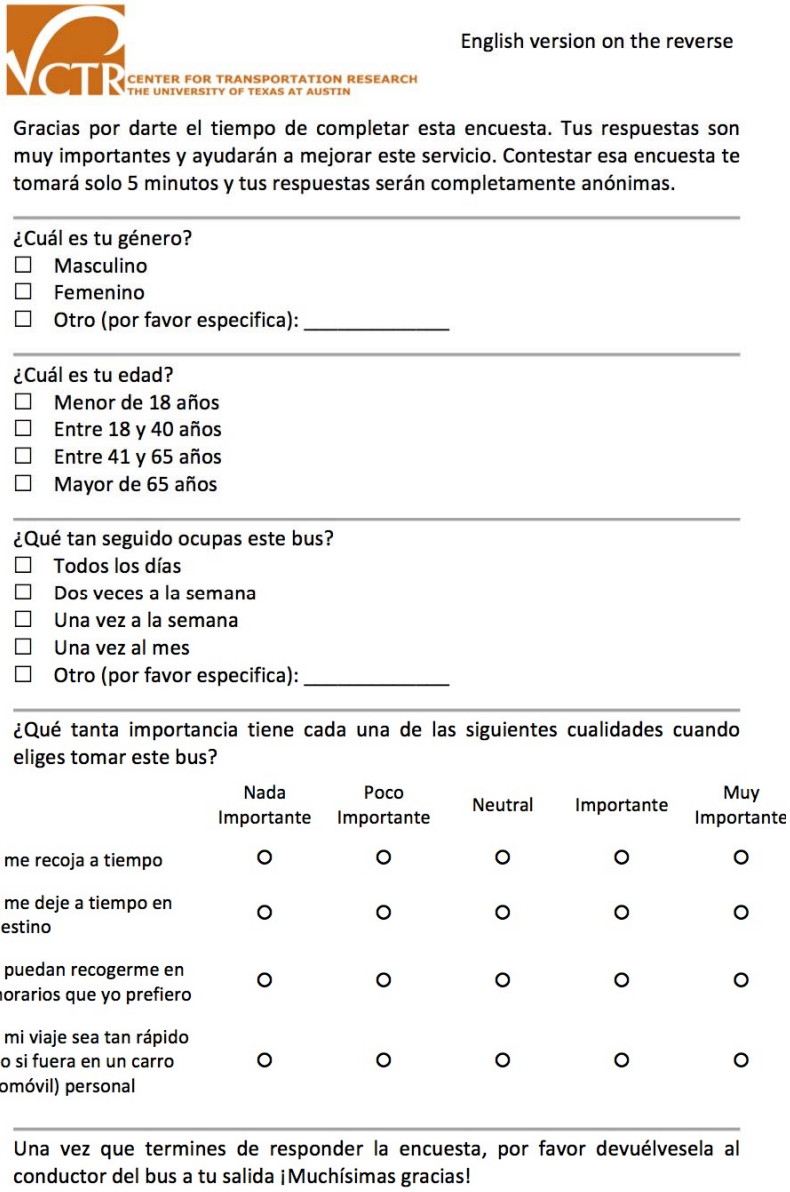
- ☐ Every Day
- ☐ Twice a Week
- ☐ Once a Week
- ☐ Once a Month
- ☐ Other (Please Specify): _____

How important is each of the following qualities when choosing to ride the bus?

	Not Important	Moderately Unimportant	Neutral	Important	Very Important
Being picked up on time	O	O	O	O	O
Being dropped off on time	O	O	O	O	O
Receiving your preferred time of travel	O	O	O	O	O
Having a quicker travel time than compared to going by car	O	O	O	O	O

Once you have finished the survey, please return it to the bus driver as your exit. Thank you and have a wonderful day!

Figure 6.1: Survey questionnaire in English



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English version on the reverse

Gracias por darte el tiempo de completar esta encuesta. Tus respuestas son muy importantes y ayudarán a mejorar este servicio. Contestar esa encuesta te tomará solo 5 minutos y tus respuestas serán completamente anónimas.

¿Cuál es tu género?
- ☐ Masculino
- ☐ Femenino
- ☐ Otro (por favor especifica): _____

¿Cuál es tu edad?
- ☐ Menor de 18 años
- ☐ Entre 18 y 40 años
- ☐ Entre 41 y 65 años
- ☐ Mayor de 65 años

¿Qué tan seguido ocupas este bus?
- ☐ Todos los días
- ☐ Dos veces a la semana
- ☐ Una vez a la semana
- ☐ Una vez al mes
- ☐ Otro (por favor especifica): _____

¿Qué tanta importancia tiene cada una de las siguientes cualidades cuando eliges tomar este bus?

	Nada Importante	Poco Importante	Neutral	Importante	Muy Importante
Que me recoja a tiempo	O	O	O	O	O
Que me deje a tiempo en mi destino	O	O	O	O	O
Que puedan recogerme en los horarios que yo prefiero	O	O	O	O	O
Que mi viaje sea tan rápido como si fuera en un carro (automóvil) personal	O	O	O	O	O

Una vez que termines de responder la encuesta, por favor devuélvesela al conductor del bus a tu salida ¡Muchísimas gracias!

Figure 6.2: Survey questionnaire in Spanish

6.3 Survey Distribution

The survey distribution preparation began in early December 2013 when the research team contacted the four agencies from whom we collected the earlier DRT data: BCAA, Del Rio, Fort Bend, and Hill Country. This initial outreach was made by calling the contact person in each agency, and explaining the task at hand and what would be required from the agency. The questionnaire was designed as an on-transit survey and therefore required the bus drivers of the systems to hand out the surveys while en route.

Within a month of the initial contact, CTR researchers corresponded via email with the agencies to keep them informed on the progress of the survey development

and address any concerns. Once the survey was finalized, the agencies were again contacted and asked to whom the surveys should be sent. At this point, the point of contact switched to another person at the agency, as shown in Table 6.1. However, two stumbling blocks arose at BCAA and Del Rio:

- Unanswered emails to BCAA led to a phone call where it was discovered that the original contact, Sara Longoria, had taken a personal leave of absence, leaving the other staff unaware of the upcoming distribution of surveys. Thus, we unfortunately could not distribute the survey to BCAA patrons.
- After 2 weeks of attempts by the staff of Del Rio, only four people had responded to the survey. So we decided that a bilingual member of our research team, Sebastian Astroza, would personally conduct the survey over 3 days: February 18 to February 20. It was still an on-board survey, but the researcher interviewed patrons directly and noted the responses, removing the pressure of filling out a paper survey. This approach yielded a better response rate.

Table 6.1: Contact information for agencies

Agency	Contact Name		Email Address	Phone Number
BCAA	Initial	Sara Longoria	sara.longoria@bizstx.rr.com	(361) 358-7229
	Final	Anna Simo	Anna.simo@bizstx.rr.com	(361) 358-5530
Del Rio	John Burns		jburns@cityofdelrio.com	(830) 703-5324
Fort Bend	Initial	James Hoss	James.hoss@co.fort-bend.tx.us	(281) 243-6746
	Final	Stephen Gipson	Stephen.Gipson@fortbendcountytx.gov	(281) 633-7433
Hill Country	Initial	Terry Reeves	treeves@takethehop.com	(325) 372-4677
	Final	Tony Austin	taustin@takethehop.com	(254) 933-3700

The surveys were sent to the agencies using FedEx; a follow-up email provided the contacts with the tracking number for the surveys and asked when the surveys would be ready for pick-up. We asked that the agencies distribute the surveys for at least 2 to 3 days to maximize response levels.

6.4 Analysis of the Survey Results

Fifty-one patrons completed the survey in Del Rio, as well as 85 in Fort Bend and 100 in the Hill Country service area. From this set of responses, we discarded six incomplete surveys from Fort Bend and seven from Hill Country. The weights for the accessibility index model were obtained according the following method: first, we scaled each importance group from 1 point to 5 points—1 point for *Not important*, 2 points for *Moderately unimportant*, 3 points for *Neutral*, 4 points for *Important*, and 5 points for *Very important*. Then, we categorized the respondents by their attributes (age, gender, etc.). Next, we calculated the average scores for each service characteristic in each category. Finally, we normalized these average scores across categories. The results are presented in Tables 6.2, 6.3, and 6.4.

Limitations in the survey dataset necessitated some changes to the weight categories:

- Only 18 men were interviewed in Del Rio, so we could not effectively compute weights by age range for men in Del Rio.
- Similarly, we could not compute weights for patrons younger than 18 years old in any of the three service areas.
- Finally, due to the lack of respondents in the 18-to-40-year-old segment for Hill Country, we redefined the age range into two categories: younger than 65 years old and older than 65 years old.

Table 6.2: Weights by age and gender for Del Rio

Segment		Count	Weights			
Gender	Age		Being picked up on time	Arriving at destination on time	Preferred time of travel	Additional DRT travel time relative to car travel time
Female	< 40	5	0.2706	0.2824	0.2235	0.2235
	Between 40 and 65	20	0.2600	0.2629	0.2571	0.2200
	> 65	8	0.2667	0.2593	0.2593	0.2147
Male	All ages	18	0.2523	0.2613	0.2492	0.2372

Table 6.3: Weights by age and gender for Fort Bend

Segment		Count	Weights			
Gender	Age		Being picked up on time	Arriving at destination on time	Preferred time of travel	Additional DRT travel time relative to car travel time
Female	< 40	8	0.2595	0.2519	0.2672	0.2214
	Between 40 and 65	22	0.2599	0.2679	0.2520	0.2202
	> 65	17	0.2694	0.2620	0.2583	0.2103
Male	< 40	19	0.2775	0.2491	0.2456	0.2278
	Between 40 and 65	10	0.2609	0.2609	0.2609	0.2173
	> 65	9	0.2615	0.2924	0.2615	0.1846

Table 6.4: Weights by age and gender for Hill Country

Segment		Count	Weights			
Gender	Age		Being picked up on time	Arriving at destination on time	Preferred time of travel	Additional DRT travel time relative to car travel time
Female	< 65	44	0.2618	0.2632	0.2515	0.2235
	> 65	21	0.2635	0.2383	0.2672	0.2310
Male	< 65	22	0.2677	0.2613	0.2452	0.2258
	> 65	13	0.2679	0.2536	0.2488	0.2297

The research team carefully considered whether to let respondents *score* their answers or *rank* their answers. Ranking is easy to implement but better used when each alternative is *not* almost equally important to respondents. Results based on forcing respondents to rank among nearly equal alternatives might be less informative. Scoring can effectively prevent this problem, but can also potentially create inaccuracy if the interpretation of results is sensitive to the change of the specific score (even if it won't change the rank reflected by scores). In our case, each service characteristic could be equally important to respondents and the accessibility index could be scaled to the necessary values without diminishing the insight the index provides. Thus, scoring was the appropriate method for this survey.

For all the agencies and for all the possible segments, the passengers are least concerned about DRT travel time relative to car travel time as compared to any other travel characteristics (and thus the associated weight for *additional DRT travel time relative to car travel time* is the smallest). The second-least important characteristic to most patrons is being served at their preferred time, except for women older than 65 in the Hill Country service area—these passengers are less concerned about arriving at their destination on time. Overall, it is difficult to discern whether the passengers are more concerned about arriving at their destination on time or being picked up on time. The relative importance of these two characteristics varies by gender, age, and agency.

Chapter 7. Developing Updated DRT Tool

7.1 The Tool Update Process

With the results of the models estimated and the weight values obtained, we were able to update the accessibility index definition and the specification of all the DRT behavioral models. As described in Section 5.2, we obtained only limited information from some of the prototypical agencies. Despite the data limitations, we went forward with developing the DRT tool for each of the five prototypical agencies: BCAA, Del Rio, Fort Bend, Hill Country, and Public Transit Services. The behavioral parameters for some demand components (or for the entire demand system in the case of Public Transit Services) were borrowed from the estimated models for other, similar agencies, as shown in Table 7.1.

Table 7.1: Summary of models

Model Name	Model Type	Del Rio	Fort Bend	BCAA	Hill Country	Public Transit Services
Total Patron Demand Generation	Linear Regression	✓	✓	✓	✓	**BCAA**
Trip Purpose Estimation	MNL	✓	✓	✓	✓	**BCAA**
Destination Zone Assignment	MNL	✓	✓	✓	✓	**BCAA**
Time of Day Allocation	MNL	✓	✓	✓	✓	**BCAA**
Drive-Alone Equivalent Travel Time	Linear Regression	**FB**	✓	**FB**	**FB**	**FB**
Pick-up Time Uncertainty	Log-linear Regression	✓	✓	**HC**	✓	**HC**
Arrival Time Delay	Log-linear Regression	✓	**DR**	**DR**	**DR**	**DR**
Accessibility Index	Weighted sum	✓	✓	**FB**	✓	**FB**

✓**:** Model was estimated **FB:** coefficients were borrowed from Fort Bend model **DR:** coefficients were borrowed from Del Rio model **HC:** coefficients were borrowed from Hill Country models **BCAA:** coefficients were borrowed from BCAA models

Since the only agency that recorded the actual drop-off time was Del Rio, the arrival time delay model from Del Rio was used for all the agencies. A similar situation occurred with the drive-alone equivalent travel time model: Fort Bend was the only agency that operated within the area of a metropolitan planning

organization with travel skims available (the Houston-Galveston Area Council). For the rest of the models, we had several options and we selected the parameters likely to yield a better performance. Since BCAA and Hill Country share the same classification of purposes, we decided to borrow the parameters of the pick-up time uncertainty model from Hill Country and use them for BCAA. We were unable to obtain survey results from BCAA and Public Transit Services, so we applied the weights from the Fort Bend survey results (Fort Bend had a greater response rate to the survey).

7.2 Improvements over the Previous Version

The researchers can identify several improvements over the previous tool developed for Brownsville, Texas (TxDOT Project 5-5178-03):

a) The DRT tool is customized for each of the five categories. According to the typology developed, this feature makes the tool applicable to all the DRT systems in Texas.

b) Models were estimated with 2010 Census data, an obvious and necessary update from the 2000 Census data of the previous tool.

c) A new dimension has been added in the patron generation: age. Now we can identify the age range (younger than 18 years old, between 18 and 65 years old, older than 65 years old) of each patron and use this age classification as an important variable in our models.

d) We have added the option of include "exterior zones," which are main cities or important places that are outside the service area, but still attract trips. For example, all the trips to San Antonio that people from the rural area of Del Rio (Val Verde County) perform almost every day.

e) The weights in the accessibility index are specific to each passenger, considering his/her age, gender, and mobility condition. These values were obtained via a survey. Also, we have kept the option to manually assign these values in the tool, just in case tool users want to measure accessibility with their own weight values.

f) Land use is an important factor in our tool, specifically for the destination zone assignment model. The previous tool was designed using a very specific land use classification. We redefined land use classification using four main categories: Agricultural, Residential, Commercial and Services, and Industrial. This classification of land use is easy to find and we have found the land use description, following our classification, for the entire Texas area.

7.3 Applicability of the Tool: "What If" Scenarios

The most important feature of our tool is the ability to conduct "what if?" scenarios to evaluate changes in fleet characteristics (supply), population demographics (demand), and service areas (scope). Tool users have the option of

saving these scenarios for future comparison as well. These results have the potential to inform a range of public transportation planning, budgetary, and policy decisions. In this study, we identify four categories of scenarios: policy, development and growth, travel patterns, and demographic and operations. The following section describes some types of scenarios that the research team believes may occur and that the model can account for. Note that this is not an exhaustive list of scenarios, but is instead a selection of scenarios that the research team considers likely to occur in the near-term future.

7.3.1 Policy Changes

Policy changes may have multiple impacts on the use of transit and may also impact the ability of transit agencies to provide effective services. In addition, policy changes may require that agencies shift to newer vehicles, different types of fuels, and other operational activities. A few examples of such policy changes are listed below, highlighting the potential impacts on DRT operation that can be examined using the tool.

Medical Consolidation

Economic pressures on physicians and hospitals have increased attention on integration and collaboration between providers (Burtley & Jacobs, 2012). Changes to the locations of medical institutions such as hospitals or in the calendar of scheduled services (in which certain services are provided on specific days) will also affect traveler choices and so affect the travel demand pattern. It makes sense to pinpoint the impact of these changes on the demand pattern in order to then determine how to improve the patron accessibility levels.

Medicaid/Medicare Changes

This kind of change will also affect the travel demand pattern for a similar reason as mentioned above. For example, Texas is not expanding Medicaid coverage to low-income adults effective January 1, 2014 (Medicaid, 2014). This policy will directly affect the number of trips generated by low-income adults for medical purposes. It is necessary to capture this impact on travel demand patterns in order to improve the patron accessibility levels.

Social Security Changes

Individuals with disabilities can benefit from the Social Security "work incentive" program that assists with work-related transportation expenses *(Using Social Security Work Incentives*). Any changes in such a program could redistribute the demand pattern. For example, in the work incentive program for blind Americans, expenses related to work (including transportation) can be fully deducted from income that is counted for Supplemental Security Income eligibility and payments. What if these expenses could be (partially) deducted from things that are not related to work? Such a policy change would increase the demand for public transportation for these individuals.

Fleet Composition Changes

Renewable energy sources have gained an increasing amount of attention in the last few decades. Transportation fuels are required by federal law to contain a minimum amount of renewable fuel each year. However, prices of such biofuels might dramatically increase if the supply of crops such as corn and grain were insufficient. State governments may request a waiver of the renewable fuel standard, which could have an impact on most modes of transportation. A waiver request did occur in Texas in 2008, but was denied (Yacobucci, 2012) .

Agency Requirement Changes

In 2003 TxDOT was required by the legislature to handle all medical trips for Medicaid, children with special health care needs, and indigent cancer patients, which is when the Medical Transportation Program (MTP) was created. MTP would arrange a free ride via contracted DRT providers or mass transit, and provide mileage reimbursement and meals and lodging for overnight stays. Although this program was terminated three sessions later, it shows that such changes are possible.

7.3.2 Development and Growth

Land Use

Transportation and land use/zoning planning decisions interact. Transport planning decisions affect land use development, and land use conditions affect transportation activity. These relationships are complex, with various interactive effects. Therefore, analyzing the impact of changing land use is essential to make transportation management policies and improve the patron accessibility levels. Land-use configurations can usually be found in a city's comprehensive plan.

For example, Belton is a city in and the county seat of Bell County. The population was 18,216 at the 2010 census. It is part of the Killeen/Temple/Fort Hood metropolitan area. Area 4 is located in far northwest Belton, generally north of FM 93 and the Nolan Creek flood plain, south of the BNSF Railroad, with frontage along the eastern right-of-way of the proposed northern extension of George Wilson Road. The area is primarily undeveloped at this time, but should be identified for future industrial development (City of Belton, Texas, 2006), which may lead to potential jobs that may have to be accessed. In addition, future residential development may occur as a consequence of industrial development. To examine the effect of this change, we could increase the proportion of industrial zones in that area to see the effect on patron accessibility levels.

Economic Development

Economic development also plays a large role in the demand for trips and travel demand patterns. In many instances, economic development occurs without interaction with other agencies, which may have to develop new infrastructure options as a consequence of the development.

Building a new facility will impact an area's travel demand pattern. According to a Georgia DOT research project, over 30% of people surveyed indicated the importance of siting a grocery or retail store, bank/credit union, doctor/health clinic, or sports facility near transit (Chapman & Frank, 2004). This finding motivates us to study the impact of such facility changes.

Again, Belton provides an example. The park master plan (part of the city's comprehensive plan) indicates that development of a new park has high priority, which means that a large neighborhood or medium-sized community park in southeastern Belton should be completed within 5 years. We could test this change to determine how to improve the patron accessibility levels.

Implementation of New Transport System

New transport infrastructure projects (such as adding a new transit line) can improve accessibility primarily in two ways: 1) new transportation infrastructure projects can in the short run reduce the travel time and/or cost required to access activities or opportunities; and 2) new transport infrastructure projects can in the long run affect the land use system, and so can affect the growth and/or redistribution of population, employment, shopping, etc., in certain zones (Warade, 2007).

The park master plan of Belton places high priority on developing the Nolan Creek Trail northward extension. This change is also expected to improve the patron accessibility levels when we implement it in our DRT tool.

7.3.3 Travel Patterns

Seasonal Trips

Some of the busiest traveling periods occur during holiday periods. The Research and Innovative Technology Administration has measured the percentage increase of these trips and found a 54% increase in long-distance trips during Thanksgiving and a 23% increase during Christmas/New Years (United States Department of Transportation). This increase in long-distance trips could result in the DRT demand decreasing, due to people traveling out of town or having family members in town who are able to take over driving responsibilities. AAA Texas predicted approximately 3 million people will travel 50 miles or more during the 2014 Memorial Day holiday weekend—a 2.1% increase from 2013 *(More Texas Travel Expected for Memorial Day*, 2014).

Another seasonal attribute to consider is that during the summer and school vacation holidays, students will not be attending school. Therefore, the DRT system will lose the demand that the schools provide, but may see an uptick in different types of trips as children attend camps, youth clubs, and other social events.

Shopping Trips

During the holidays and after what we are terming "payment days" (which can include Social Security, unemployment or disability payments, or standard

paycheck cycles), people may also have more free time and access to more money for activities they may have delayed. It is then that they are more likely to engage in shopping activities, medical trips, trips associated with children, social/leisure type trips, and trips to visit families. Therefore, we can reasonably include a scenario in which the number of shopping trips increases at the first of the month and around major holidays (Thanksgiving, Christmas, Easter, and other major religious holidays), or when social service type checks are known to be issued (monthly or biweekly).

Emergency Situations

While Texas is not a state that sees multiple major emergencies, the state is subject to hurricane season along the Gulf Coast area and, in recent years, wildfires, such as the Bastrop Wildfire in 2012.

Although the last *major* evacuation of Texas cities (including Galveston, parts of Houston, Brazoria County, and Matagorda County) occurred in 2008 during Hurricane Ike, hurricane season occurs in Texas from June 1 to November 30 of each year. A multitude of emergency situations could arise that could require an evacuation and thus we should always be ready for one. The Texas government already provides a dial service for those in need of assistance during an evacuation, but other cities around the country are also utilizing city public transportation systems to assist in such situations as well (Schwartz & Litman, 2008). Therefore, it is essential to include a scenario in the tool wherein all of the DRT fleet is in use for a required evacuation, so that the user can assess the implications of transporting people in and out of the city.

7.3.4 Demographic and Operations

Population Increase

The population size of Texas in 2012 peaked to over 25 million people and is continuing to grow. As the overall population grows, the proportion of older Texans is increasing too. The 2012 U.S. Census Bureau forecasted that the population size of those aged 60 and older will increase throughout the next 20 years, and further. Table 7.2 depicts these projections.

Table 7.2: Projected Texas population

Age Group	2012	2020	2030
0 to 19	30.3%	30.6%	29.8%
20 to 39	28.4%	27.3%	27.2%
40 to 59	25.6%	23.7%	22.8%
60+	15.7%	18.5%	20.2%

Change in Vehicle Fleet

At some point, the service demand of an area could exceed the capacity of the current DRT vehicle fleet system, due to population increase or a regional change in mode choice. At this point, the agency might decide it to purchase another vehicle for the fleet.

Looking at the opposite side of the spectrum, a vehicle fleet could potentially decrease in size due to a substantial decrease in profits or a new regulation restricting the type of vehicles used (resulting in vehicles being rotated out of service).

7.4 Sensitivity Test Analysis

Of the scenarios listed in the previous sections, the team chose the following scenarios to include in the tool. Requirements for inclusion included presenting a logical fit and the ability to be estimated within reason:

a) Additional vehicle in the fleet (ADD VEH): one vehicle with a capacity to hold 10 patrons is added to the fleet.

b) Elderly population increment (ELD POP): the elderly population (65 years or older) is increased around 10% in each zone.

c) Seasonal increment of shopping trips (SHOP TRIPS): the number of trips with a shopping purpose is increased around 20%.

d) Economic development (ECON DEV): the percentage of land use dedicated to industrial and residential uses are both increased 20% for 10 of the zones (randomly selected).

These four scenarios are compared to a base scenario (BASE), the one that we constructed using the fleet, demographic, and operations information collected early in the project. We ran all the scenarios considering only one day during the fall season. The results are presented in Table 7.3. In the table, we've reported some of the economic dimensions that are presented in the tool: revenue, operation cost, and percentage of patrons served. Also we've added the average inconvenience. The inconvenience value corresponds to the weighted sum of the average number of minutes late patrons from this census block group are arriving at their destination, the average number of minutes difference between scheduled and actual pick-up, the average difference in minutes between the time patrons spend in the DRT vehicle and the equivalent time it would have taken them if they were able to drive a personal vehicle, and the percentage of the patrons from this zone that were not able to be scheduled during this period. Then, the inconvenience value is divided by the weight of the minutes late arriving to the destination—the travel dimension that, in general, is the most important for the patrons (it has the highest weight). These inconvenience values are averaged so that each service area zone is assigned a final inconvenience index value representing minutes of delay, with lower values representing higher accessibility.

In the tool, users have the option of calculating an accessibility index based on this inconvenience measure. This accessibility index goes from 0 to 1, with a value of 0 for the zone with lowest accessibility and a value of 1 for the zone with highest accessibility. Users can compute a general accessibility measure across all patrons, times of day, and trip purposes within each service area zone or a specific disaggregate accessibility measure for any combination of population groups (defined by gender, age, and mobility impairment), time of day, and trip purposes. In Table 7.3 we report the general inconvenience index.

Table 7.3: Scenarios analysis

Prototypical Agency (Category Label)	Dimension	Scenarios				
		BASE	ADD VEH	ELD POP	SHOP TRIPS	ECON DEV
Fort Bend (Small Areas)	Average Inconvenience (min)	9.7916	9.7916	10.1314	10.6294	9.8263
	Revenue ($)	1,887	1,998	1,887	1,887	1,887
	Operation cost ($)	11,441	12,114	11,441	11,441	11,441
	Percentage of patrons served	100%	100%	100%	100%	100%
Public Transit Services (Medium Areas)	Average Inconvenience (min)	6.455	6.38	6.5123	6.456	6.455
	Revenue ($)	1,768	1,786	1,768	1,768	1,768
	Operation cost ($)	10,007	10,100	10,007	10,007	10,007
	Percentage of patrons served	39.76%	42.93%	36.63%	39.76%	39.76%
Hill Country (Large Areas)	Average Inconvenience (min)	7.004	7.004	7.054	6.808	6.973
	Revenue ($)	8,991	8,991	8,991	8,991	8,991
	Operation cost ($)	54,513	54,513	54,513	54,513	54,513
	Percentage of patrons served	18.7%	18.7%	18.6%	18.7%	18.7%
Del Rio (Rural Areas)	Average Inconvenience (min)	6.7889	6.7757	7.0057	6.7921	6.7886
	Revenue ($)	1,665	1,776	1,665	1,665	1,665
	Operation cost ($)	10,095	10,768	10,095	10,095	10,095
	Percentage of patrons served	27.90%	30%	23.06%	29.24%	27.92%
BCAA (Non-Medicaid)	Average Inconvenience (min)	5.0711	5.0576	5.0876	5.0947	5.0946
	Revenue ($)	2,442	2,553	2,442	2,442	2,442
	Operation cost ($)	14,806	15,479	14,806	14,806	14,806
	Percentage of patrons served	54.51%	58.47%	54.06%	55.36%	55.36%

In almost all the categories, the addition of an extra vehicle in the fleet makes the zones, on average, more accessible (average inconvenience decreases). There are only two exceptions: a) Small Areas category, where the extra vehicle seems to be unnecessary (the system is satisfying the entire demand, even in the base scenario), and b) Large Areas category, where an extra vehicle does not make a significant difference in the operation of a huge fleet (Hill Country operates around 123 vehicles per day). In all of the categories we can see an increase in cost and revenue, both directly related to the expenses and benefits of the operation of an additional vehicle.

The increment of elderly population decreases the accessibility (we can observe higher values for the delay minutes when we compare this scenario with the base) in all the categories. The explanation is quite simple: we are increasing the population of a very important group of DRT users (and consequently we are increasing the demand for DRT) without changes in the fleet or operation system. In this scenario, agencies have to transport more people with the same resources. Also, elderly people tend to travel in the afternoon, which increases the *arrival time delay* (minutes late a patron arrives at his/her destination) and the *pick-up time uncertainty* (number of minutes difference between when patron pick-up was scheduled and when it was completed)—two of the main components of accessibility.

The seasonal effect in shopping trips decreases accessibility in almost all the categories (except for Large Areas category), with a significant change in accessibility for the Small Areas and Rural Areas categories. In these two categories, we found during the estimation of the behavioral models that shopping trips have more pick-up uncertainty. This effect, plus the obvious effect of trying to satisfy more trips with the same fleet, produces the decrease in accessibility. According to the behavioral models estimated, Hill Country patrons perform shopping trips preferably in the morning, and morning trips are associated with a smaller arrival time delay. This reduction in delay produces an improvement in accessibility for Hill Country patrons (Large Areas category).

In terms of economic development, no common pattern was discerned. Percentages of land use dedicated to residential and industrial have different impacts in the behavioral models for each category. In cases like these, users can examine accessibility developments in detail for each of the zones. Also, the tool provides an output that is very easy to draw in ArcGIS, allowing graphic analysis and thus a better understanding of the accessibility changes across the service region.

Chapter 8. Training Workshop in the Use of the Updated DRT Tool

In close association with TxDOT-PTN and the DRT agencies involved with this project, the team organized a training workshop to (a) familiarize department and transit agency personnel with the comprehensive and customized DRT accessibility computation approach, (b) provide instruction in the use of the software tool to evaluate accessibility for specific patron populations, travel purposes, times of day, days of the week, seasons of the year, and spatial areas, and (c) discuss how to conduct scenario analysis and use the tool for proactive DRT planning.

The workshop was held at the CTR offices on Friday, August 22, 2014, from 10:30 a.m. to noon and it was offered also as a webinar. The research team made a presentation about the features and uses of the software followed by a detailed demonstration of the tool. Most of the participants expressed positive feedback about the tool and indicated willingness to use the tool to improve their operations and predict the future needs of their riders. The list of participants is available in Appendix O.

The workshop provided an opportunity for the team to hear the opinions and concerns of transit agencies regarding the DRT tool. In addition, an informal model validation exercise was developed. Most of the attendees expressed the desire of work with the tool as soon as possible.

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Appendix A: Counties Served by DRT Services

No.	DRT Agency	Counties served
1	Alamo Area Council of Governments (AACOG)	Gillespie, Kerr, Kendall, Comal, Bandera, Medina, Frio, Atascosa, Kames, Wilson, and Guadalupe
2	Ark-Tex Council of Governments (ATCOG)	Lamar, Red River, Bowie, Delta, Hopkins, Franklin, Titus, Morris, and Cass
3	Aspermont Small Business Development Center	Knox, Kent, Stonewall, Haskell, Throckmorton, Fisher, and Jones
4	Bee Community Action Agency (BCAA)	McMullen, Live Oak, Bee, Refugio, and Aransas
5	Brazos Transit District	Robertson, Leon, Houston, Nacogdoches, Shelby, San Augustine, Sabine, Angelina, Trinity, Madison, Brazos, Burleson, Washington, Grimes, San Jacinto, Walker, Montgomery, Liberty, Tyler, and Polk
6	Capital Area Rural Transportation System (CARTS)	Burnet, Williamson, Blanco, Travis, Lee, Bastrop, Hays, Caldwell, and Fayette
7	Central Texas Rural Transit District	Schackelford, Stephens, Nolan, Taylor, Callahan, Eastland, Erath, Runnels, Coleman, Brown, and Comanche
8	Cleburne, City of	Johnson
9	Collin County Committee on Aging (CCART)	Collin
10	Colorado Valley Transit	Colorado, Austin, Waller, and Wharton
11	Community Action Council of South Texas (CACST)	Duval, Zapata, Jim Hogg, and Starr
12	Community Services, Inc.	-
13	Concho Valley Transit District	Sterling, Coke, Reagan, Irion, Tom Green, Concho, McCulloch, Crockett, Schleicher, Menard, Sutton, and Kimble
14	Del Rio, City of	Val Verde
15	East Texas Council Of Governments (ETCOG)	Rains, Wood, Camp, Upshur, Marion, Van Zandt, Smith, Gregg, Harrison, Henderson, Cherokee, Rusk, Panola, and Anderson
16	El Paso, County of	-
17	Fort Bend County Rural Transit District	Fort Bend
18	Galveston County Transit District	Galveston
19	Golden Crescent Regional Planning Association (GCRPC)	Gonzales, Lavaca, Dewitt, Goliad, Victoria, Jackson and Calhoun
20	Gulf Coast Center	Brazoria
21	Heart of Texas Council of Governments (HOTCOG)	Bosque, Hill, McLennan, Falls, Limestone, and Freestone
22	Hill Country Transit District	Mason, San Saba, Llano, Mills, Lampasas, Hamilton, Coryell, Bell, and Milam
23	Kleberg County Human Services	Kleberg and Kenedy
24	Lower Rio Grande Valley Development Council	Hidalgo, Willacy, and Cameron

No.	DRT Agency	Counties served
25	Panhandle Community Services, Inc. (PCS)	Dallam, Sherman, Hansford, Ochiltree, Lipscomb, Hartley, Moore, Hutchinson, Roberts, Hemphill, Oldham, Potter, Carson, Gray, Wheeler, Deaf Smith, Randall, Armstrong, Donley, Collingsworth, Parmer, Castro, Swisher, Briscoe, Hall, and Childress
26	Public Transit Services	Jack, Palo Pinto, and Parker
27	Rolling Plains Management Corporation (RPMC)	Cottle, Foard, Hardeman, Wilbarger, Wichita, Baylor, Archer, and Young
28	Rural Economic Assistance League, Inc. (REAL)	Brooks, Jim Wells, and San Patricio
29	Senior Center Resources and Public Transit, Inc. (SCRPT)	Hunt
30	Services Program for Aging Needs (SPAN)	Denton
31	South East Texas Regional Planning Commission (SETRPC)	Hardin, Jefferson, and Orange
32	South Padre Island	South Padre Island
33	South Plains Community Action Association, Inc. (SPCAA)	Bailey, Lamb, Hale, Floyd, Motley, Cochran, Hockley, Lubbock, Crosby, Dickens, King, Yoakum, Terry, Lynn, Garza, Scurry, and Mitchell
34	Southwest Area Regional Transit District	Edwards, Real, Kinney, Uvalde, Maverick, Zavala, Dimmit, and La Salle
35	STAR Transit	Rockwall, Kaufman, Ellis, and Navarro
36	Texoma Area Paratransit System, Inc.	Clay, Montague, Cooke, Grayson, Fannin, and Wise
37	The Transit System, Inc.	Hood and Somervell
38	Webb County Community Action Agency	Webb
39	West Texas Opportunities, Inc. (WTO)	Gaines, Dawson, Borden, Andrews, Martin, Howard, Hudspeth, Culberson, Reeves, Loving, Winkler, Ector, Midland, Glasscock, Ward, Crane, Upton, Pecos, Jeff Davis, Presidio, Brewster, and Terrell

Appendix B: DRT Agencies Contact Information

No.	DRT Agency Name	Website	Contact Person	Phone	Mail
1	Alamo Area Council of Governments (AACOG)	http://www.aacog.dst.tx.us/index.aspx?nid=67	-	210-362-5259	-
2	Ark-Tex Council of Governments (ATCOG)	http://www.atcog.org/	Casandra Antoine	903-832-8636	-
3	Aspermont Small Business Development Center	-	Dana Myers	940-989-3538	-
4	Bee Community Action Agency (BCAA)	-	-	361-358-7229	-
5	Brazos Transit District	http://www.btd.org/Paratransit.htm	Wendy Weedon	-	wendy@btd.org
6	Capital Area Rural Transportation System (CARTS)	http://ridecarts.com/services/community-transit	Katie Hutchins	-	Katie@ridecarts.com
7	Central Texas Rural Transit District	http://www.cityandruralrides.com/index.htm	Heather R Langley	-	heather@cityandruralrides.com
8	Cleburne, City of	http://www.ci.cleburne.tx.us/cletran.aspx	Julie A. Floyd	817-645-0924	Julie.Floyd@cleburne.net
9	Collin County Committee on Aging (CCART)	-	Rep Pledger	-	pledgerr@ccartcc.com
10	Colorado Valley Transit	http://www.gotransit.org/austincounty.htm	-	979-732-6281	-
11	Community Action Council of South Texas (CACST)	http://www.cacst.org/transportation.html	Noelia Ruiz	956-487-0068	-
12	Community Services, Inc.	-	-	-	-
13	Concho Valley Transit District	http://www.cvcog.org/cvcog/trans_urban.html	-	325-947-8729	-
14	Del Rio, City of	http://cityofdelrio.com/index.aspx?NID=431	John Burns	830-703-5324	-
15	East Texas Council Of Governments (ETCOG)	http://www.etcog.org/234/Transportation.htm	John Hedrick	-	john.hedrick@etcog.org
16	El Paso, County of	-	-	-	
17	Fort Bend County Rural Transit District	http://www.co.fort-bend.tx.us/getsitepage.asp?sitepage=23544	Cindy L. Sumrall	-	Transit@co.fort-bend.tx.us

No.	DRT Agency Name	Website	Contact Person	Phone	Mail
18	Galveston County Transit District	http://www.islandtransit.net/	-	-	-
19	Golden Crescent Regional Planning Association (GCRPC)	http://www.gcrpc.org/gcrpc_transit.htm	Lisa Cortinas	-	lisac@gcrpc.org
20	Gulf Coast Center	http://www.gulfcoastcenter.org/connect_transportation.aspx	James Hollis	409-944-4446	jamesh@gulfcoastcenter.org
21	Heart of Texas Council of Governments (HOTCOG)	http://www.hotcog.org/pages/transportation.aspx	-	-	-
22	Hill Country Transit District	http://www.takethehop.com/	Carole Warlick	-	cwarlick@takethehop.com
23	Kleberg County Human Services	https://www.hotras.com/sys/profile.taf?profiletype=service&textonly=&recordid=1164995&_UserReference=AC1E0208471973AEC5AE0626E06550B3AEC9	Becky Greif	-	beckygreif@hotmail.com
24	Lower Rio Grande Valley Development Council	http://www.lrgvdc.org/valleymetro/index.html	Rodney Gomez	-	RGomez@lrgvdctransit.org
25	Panhandle Community Services, Inc. (PCS)	-	-	806-372-2531	-
26	Public Transit Services	http://www.publictransitservices.org/home.php	-	940-328-1391 Ext 101	-
27	Rolling Plains Management Corporation (RPMC)	http://www.rollingplains.org/transportation.php	-	940-684-1571	-
28	Rural Economic Assistance League, Inc. (REAL)	http://realinc.org/transportation.php	-	800-634-8082	-
29	Senior Center Resources and Public Transit, Inc. (SCRPT)	http://www.connectioninfo.org/	David Caldwell	-	dcaldwell@scrpt.org
30	Services Program for Aging Needs (SPAN)	http://www.span-transit.org/v2/services.html	Nic Gray	-	nicholasg@span-transit.org
31	South East Texas Regional Planning Commission (SETRPC)	www.setrpc.org/ter/index.php?option=com_content&view=article&id=12&itemid=20	D'Juana Davillier	-	ddavillier@setrpc.org
32	South Padre Island	http://myspi.org/department/division.php?fDD=13-112	Jesse Arriaga	956-761-3245	-

No.	DRT Agency Name	Website	Contact Person	Phone	Mail
33	South Plains Community Action Association, Inc. (SPCAA)	-	Brian Baker	-	bbaker@spcaa.org
34	Southwest Area Regional Transit District	http://www.paseoswart.org/	Sarah Hidalgo-Cook	-	scook@paseoswart.org
35	STAR Transit	http://www.terrelldepot.com/KART%20Home%20page.htm	-	-	-
36	Texoma Area Paratransit System, Inc.	-	-	903-893-4601	-
37	The Transit System, Inc.	-	Barbara L. Perry	254-897-2964	transit@windstream.net
38	Webb County Community Action Agency	http://webbcounty.com/CommunityActionAgency/ElAguila/default.aspx	Robert Martinez	-	romartinez@webbcountytx.gov
39	West Texas Opportunities, Inc. (WTO)	http://www.gowto.org/index.cfm?fuseaction=dep_intro&dept_id=7	Karen Faulkner	-	wtotrans@gmail.com

Appendix C: Prototypical Agencies Contact Information

No.	DRT Agency Name	Contact Person	Phone	Email
1	Fort Bend County Rural Transit District	James Hoss	281-243-6701	james.hoss@fortbendcountytx.gov
2	Public Transit Services	Reta Brooks	940-328-1391x101	rbrooks@publictransitservices.org
3	Hill Country Transit District	Terry Reeves	325-372-4677	treeves@takethehop.com
4	City of Del Rio	John Burns	830-734-3948	jburns@cityofdelrio.com
5	Bee Community Action Agency (BCAA)	Anna Simo	361-358-7229	anna.simo@bizstx.rr.com

Appendix D: Demographics of Prototypical Agencies

- *Fort Bend County Rural Transit District*: The agency operates only in the county of Fort Bend, which has 76 census tracts. This area is in southeast Texas, just outside of Houston. Most of the area is largely populated, with few exceptions. Fort Bend County has a total population of 585,375 people, and a population density of 679.5 people per square mile. The median age of residents is on average 36.19 years. The county has 187,384 households, and 40,743 of these are renters (21.74%).

- *Public Transit Services*: This agency is composed of three counties—Jack, Palo Pinto, and Parker—in northeast Texas, a fairly rural area. The county with the largest population is Parker, with 116,927 residents, while Jack County only has 9,044 residents. The population density ranges from 9.93 to 129.4 people per square mile. The percentage of households that rent in this area is about 25.7%, and 33.69% of this population is over 50 years old, making DRT a good fit for this area.

- *Hill Country Transit District*: This agency is composed of nine counties in central Texas. Most of the counties are in rural areas, leading to lower population counts and lower population density. The largest county serviced by this agency is Bell County, with a population of 114,035, while the smallest is Mills County with just 1,975 residents. The total population of all nine counties totals 472,954. Average household size ranges from 2.1 to 2.71, with the overall average household size at 2.45. The area has many rental properties—76,777 across all nine counties (out of the 171,963 households total); rentals thus comprise a significant percentage (44.6%) of the properties in the area. The median age of the population included in the agency's jurisdiction is 42.4 years, and 116,719 residents are over the age of 50 years, making up 24.6% of the population.

- *City of Del Rio*: This agency operates in only one county, Val Verde, located on the Edwards Plateau along the Texas-Mexico border. The population count as of 2010 is 48,879 residents within an area of 3950.54 square miles. This results in a population density of 12.88 people per square mile and the median age of the population is 32.07 years. Of the 15,654 households in the county, 5905 of them are rented, which is over 37%. Also, a significant portion of the population is over 50 years in age. All of these factors indicate that this county's population would use the DRT lines.

- *Bee Community Action Agency (BCAA)*: The BBCA operates in five counties located between San Antonio and Corpus Christi. The populations in these counties range from 707 in McMullen to 31,861 in Bee County. The total population within the BCAA district is 49,313. The median age of the

population ranges from 37.34 to 49.80 years, and the average household size ranges from 1.89 to 2.68. Over 54% of the households within the counties are rented, and 55.65% of the population is over the age of 50 years.

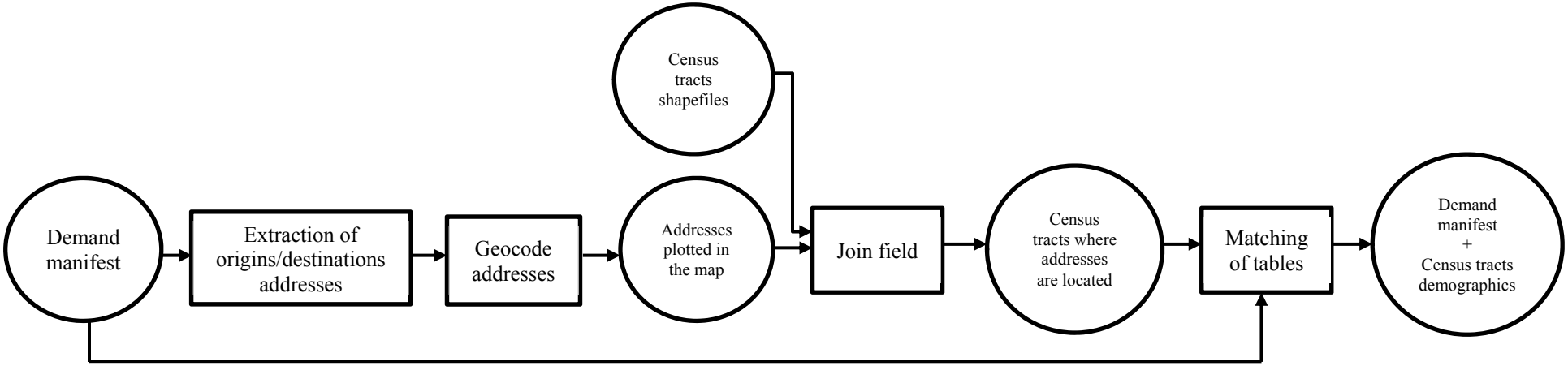
Appendix E: Behavioral Demand Models Used in the DRT Accessibility Tool

Model name	Model type	Estimation software	Variables involved (dependent variable in italics)
Total Patron Demand Generation	Regression/Tobit	GAUSS	*Total number of patrons in each census tract* ln(Total population size within census tract) Average household size within census tract Distance from census tract centroid to nearest transit route (miles) Percentage of census tract households that rent Percent of census tract population aged 50–64 Percent of census tract population aged 65 or older
Trip Purpose Estimation	Percentage	SPSS	*Trip purpose (alternatives are Education/School, Recreation, Medical/Therapy, Shopping and Work)* Passenger gender Whether the passenger is mobility-impaired or not
Destination Zone Assignment	Multinomial Logit	GAUSS	*Destination zone of each trip* Population density of each census tract Distance from census tract centroid to nearest transit route (miles) Percent of census tract area zoned for Apartments Percent of census tract area zoned for Commercial Percent of census tract area zoned for Retail Percent of census tract area zoned for Manufacturing Passenger gender Trip purpose Whether the passenger is mobility-impaired
Time of Day Allocation	Multinomial Logit	GAUSS	*Time of day allocation for each trip (alternatives: travel out in the AM and return in the AM, travel out in the AM and return in the PM, travel out in the PM and return in the PM)* Distance between origin and destination census tract centroids (miles) Trip purpose Whether the passenger is mobility-impaired

Appendix E: Behavioral Demand Models Used in the DRT Accessibility Tool (cont.)

Model name	Model type	Estimation software	Variables involved (dependent variable in italics)
In-Vehicle Travel Time	Non-linear Least Squares	SPSS	*In-vehicle travel time for each trip (minutes)* Distance between origin and destination census tract centroids (miles) Community size associated to each trip (alternatives: urban area, suburban area, second city area, town area, rural area)
Drive Alone Equivalent Travel Time	Linear Regression	SPSS	*Drive alone equivalent travel time for each trip (minutes)* Distance between origin and destination census tract centroids (miles)
Pick-up Time Uncertainty	Log-linear Regression	SPSS	*Difference in time between scheduled and actual pick-up for each trip (minutes)* Trip purpose Whether the passenger is mobility-impaired Time of day allocation for each trip Season of the year when the trip is performed
Arrival Time Delay	Log-linear Regression	SPSS	*Minutes late arriving at destination* Whether the passenger is mobility-impaired Time of day allocation for each trip Season of the year when the trip is performed Passenger gender
Accessibility Index	Linear Regression	SPSS	*Accessibility value for each census tract* Average patron arrival time delay Average patron pick-up time uncertainty Average patron difference between in vehicle and drive alone equivalent travel times Percent of unmet demand in census tract

Appendix F: Detailed Merging Process of Spatial GIS Data and Trips



- **Demand manifest:** spreadsheet with all the DRT patron trips for one year.
- **Extraction of origins/destinations addresses:** copy of all the addresses to a separate Excel file that will serve as input in ArcGIS.
- **Geocode addresses:** ArcGIS tool to locate addresses in a map.
- **Addresses plotted in the map:** several points, one per origin and destination, graphically located in the map.
- **Census tracts shapefiles:** spatial GIS data of the area of service at a census-tract level (including all the sociodemographic characteristics).
- **Join field:** ArcGIS tool to join the points in the map with the information about the area (census tracts) where they are located.
- **Census tracts where addresses are located:** ArcGIS table with the census tracts where each address is located and its respective sociodemographic characteristics.
- **Matching of tables:** SPSS (statistical software) process to append the census tracts information to the demand manifest.
- **Demand manifest + Census tracts demographics:** resulting Excel file corresponding to a detailed demand manifest, in a trip origin/destination format, including a complete description of the census tract where the origin and destination are located.

Appendix G: Total Patron Demand Generation Results

Parameters	Del Rio		Fort Bend		BCAA		Hill Country	
	Coeff.	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Constant	-131.841	-4.42	-108.843	-3.12	-96.725	-3.88	-69.550	-3.14
General Characteristics								
Natural Logarithm of Total Size Census Zone Population	4.283	2.73	9.294	2.70	8.94	3.36	7.243	2.90
Average Household Size within Census Zone	20.861	2.99						
Local Census Zone Population Percentages								
Percentage of Census Zone Households that Rent	48.071	5.73	26.988	2.31	28.745	3.64	11.587	1.45
Percentage of Census Zone Population Aged 50–64					70.843	1.68		
Percentage of Census Zone Population Aged 65 or Older	204.099	5.07	112.046	2.69	45.580	2.33	74.534	3.09
Percentage of Census Zone Population Hispanic or Latino	13.051	1.43	10.172	1.10	29.41	3.96	103.87	4.58
	Sample Size: *34* R2: *0.720*		Sample Size: *76* R2: *0.214*		Sample Size: *62* R2: *0.351*		Sample Size: *111* R2: *0.241*	

Appendix H.1: Trip Purpose Estimation Results (Del Rio and Fort Bend)

Parameters	Del Rio						Fort Bend					
	Trip Purpose (Base: Education)						Trip Purpose (Base: Education)					
	Medical		Work		Other		Medical		Work		Other	
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Constant	2.367	6.14	4.299	10.95	2.268	4.79	-1.454	-69.72	-1.032	-58.30	0.371	31.48
Patron Characteristics (Base: Mobile Female Adult)												
Mobility-Impaired			-5.533	-5.28	-1.301	-2.96	2.056	52.02	0.607	13.09	0.535	15.71
Male			-1.457	-4.90	-0.491	-1.40						
Youth	1.268	1.68										
Elderly	0.983	2.41	-0.504	-1.30								
	Sample Size: *414* Log-Likelihood at Convergence: *-351.942*						Sample Size: *45,071* Log-Likelihood at Convergence: *-53,442.49*					

Appendix H.2: Trip Purpose Estimation Results (BCAA and Hill Country)

Parameters	*BCAA*								*Hill Country*							
	Trip Purpose (Base: Education)								**Trip Purpose (Base: Education)**							
	Medical		**Recreation**		**Shopping**		**Work**		**Medical**		**Recreation**		**Shopping**		**Work**	
	Coeff.	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**		
Constant	-0.919	-13.72	-1.486	-25.39	-3.510	-66.31	-0.155	-3.26	3.461	99.00	1.436	37.31	0.856	20.66	0.799	19.03
Patron Characteristics (Base: Mobile Female Adult)																
Mobility-Impaired	3.454	20.14	3.750	21.77	3.804	20.53	1.567	8.64	1.810	21.61	1.222	13.19	1.758	18.65		
Male	0.589	7.88	-0.680	-7.42	0.634	8.25										
Youth	-7.795	-11.08	-5.421	-15.13			-6.245	-24.53								
Elderly	4.846	15.00	6.315	19.57	6.704	20.75	3.439	10.58								
	Sample Size: *16,352* Log-Likelihood at Convergence: *-9,472.47*								Sample Size: 44,279 Log-Likelihood at Convergence: -34,028.10							

Appendix I: Destination Zone Assignment Results

	Del Rio		Fort Bend		BCAA		Hill Country	
Parameters	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Patron Characteristic Interactions (Base: Mobile Female Adult)								
Total Population of Census Zone					-0.140	-12.64	-0.200	-9.44
Male * Total Population of Census Zone					-0.010	-4.97		
Distance between the Census Zone and the Origin Zone Centroid	-0.734	-2.63	-0.002	-13.09	-0.104	-14.65		
Mobility Impaired * Distance between the Census Zone and the Origin Zone Centroid			-0.075	-8.44				
Trip Purpose Interactions (Base: Education)								
Medical * Percent of Census Area Zoned for Agricultural			-0.025	-3.42	0.227	5.29	-0.132	-42.12
Medical * Percent of Census Area Zoned for Communication & Services	-9.588	1.75					0.411	6.64
Medical * Percent of Census Area Zoned for Industrial	23.510	2.62						
Medical * Percent of Census Area Zoned for Residential	-6.015	-1.77					-3.929	-11.33
Work* Percent of Census Area Zoned for Commercial & Services					1.080	1.27		
Work * Percent of Census Area Zoned for Industrial							1492.218	2.92
Work * Percent of Census Area Zoned for Residential			-0.759	1.68			-20.087	-8.52
Recreation * Percent of Census Area Zoned for Industrial							1432.04	4.48
Recreation * Percent of Census Area Zoned for Residential							-19.39	-10.31
Shopping* Percent of Census Area Zoned for Commercial & Services					19.015	5.76		
Shopping * Percent of Census Area Zoned for Residential							-11.767	-55.33
Other * Perfect of Census Area Zoned for Commercial & Services			3.261	1.50				
	Sample Size: *414* Log-Likelihood: *-261.4*		Sample Size: *45,071* Log-Likelihood:*-11,759.2*		Sample Size:*16,352* Log-Likelihood:*-30,414.7*		Sample Size: *44,279* Log-Likelihood:*-30,995.3*	

Appendix J: Time of Day Allocation Results

Parameters	Del Rio				Fort Bend				BCAA				Hill Country			
	Travel Time of Day (Base: Travel Out in the AM and Return in the AM)				Travel Time of Day (Base: Travel Out in the AM and Return in the AM)				Travel Time of Day (Base: Travel Out in the AM and Return in the AM)				Travel Time of Day (Base: Travel Out in the AM and Return in the AM)			
	Travel Out in the AM and Return in the PM		Travel Out in the PM and Return in the PM		Travel Out in the AM and Return in the PM		Travel Out in the PM and Return in the PM		Travel Out in the AM and Return in the PM		Travel Out in the PM and Return in the PM		Travel Out in the AM and Return in the PM		Travel Out in the PM and Return in the PM	
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Constant	2.317	8.19	0.144	0.37	3.674	48.15	0.633	7.00	2.183	27.54	-1.285	-10.72	1.680	46.18	0.772	26.36
Patron Characteristics (Base: Mobile Female Adult)																
Mobility-Impaired			2.124	4.12	0.664	7.74	0.564	5.38			-0.954	-7.10				
Male	-2.129	-5.42	-1.391	-1.94					0.949	12.01	-0.277	-2.17				
Youth									5.839	9.87						
Elderly			-0.662	-1.39					-0.601	-8.38	-0.615	-5.25				
Trip Characteristics																
Distance Between Origin and Destination Zone Centroids in miles					0.048	19.61			0.058	15.31			0.015	12.411	0.011	7.45
Trip Purpose (Base: Education)																
Medical	2.730	5.50			-2.143	-22.95	-1.370	-11.36	-2.523	-27.58	1.035	8.35	0.909	27.15		
Work					0.502	3.27	1.179	6.96	-0.903	-8.42	-0.809	-3.13	3.449	10.81	-0.738	-1.68
Recreation																
Shopping									-2.729	-27.89			-1.071	-16.46	-0.154	-2.52
Other	-1.044	-2.77			-0.430	-4.90	-0.291	-2.69								
	Sample Size: *414* Log-Likelihood: *-193.42*				Sample Size: *45,071* Log-Likelihood: *-12,205.99*				Sample Size: *16,467* Log-Likelihood: *-4,160.43*				Sample Size: *44,279* Log-Likelihood: *-26,800.13*			

Appendix K: Drive-Alone Equivalent Travel Time (Fort Bend)

Drive-Alone Equivalent Time in Minutes = 1.23+1.65 [*Distance between Origin and Destination Census Tract Centroids, in Miles*]

Sample Size: *90,142*
R^2: *0.521*

Appendix L: Pick-Up Time Uncertainty Results

Parameters	*Del Rio*		*Fort Bend*		*Hill Country*	
	Coeff.	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Constant	0.389	2.46	1.928	71.81	0.787	57.66
Travel Time of Day (Base: Travel Out in the AM)						
Travel Out in the PM			0.116	4.44		
Trip Purpose (Base: Education)						
Medical	0.518	3.17			0.041	5.10
Work	0.324	1.98	-0.089	-5.32	-0.090	-4.34
Other	0.302	1.73	0.271	25.76		
Travel Season (Bases: Travel in Spring or Fall)						
Travel in the Summer					-0.014	-2.87
Travel in the Winter			0.039	3.56	-0.027	-3.84
Patron Characteristics (Bases: Mobile Female Adult or Youth)						
Mobility-Impaired			0.121	9.42	0.024	5.34
Male	0.075	1.34				
Elderly	-0.070	-1.41				
Destination Zone Characteristics (Base: Interior Zone)						
Exterior Zone			0.167	15.45	0.076	5.088
	Sample Size: *414* R^2: *0.247*		Sample Size: *45,071* R^2: *0.174*		Sample Size: *44,279* R^2: *0.120*	

Appendix M: Arrival Time Delay Results

Parameters	*Del Rio*	
	Coefficient	**t-stat**
Constant	0.738	18.39
Travel Time of Day (Base: Travel Out in the AM)		
Travel Out in the PM	0.238	2.80
Trip Purpose (Bases: Education, Work or Other)		
Medical	0.140	1.79
Patron Characteristics (Bases: Mobile Adult or Youth)		
Mobility-Impaired	-0.080	-1.23
Elderly	-0.064	-1.35
Destination Zone Characteristics (Base: Interior Zone)		
Exterior Zone	0.906	11.85
Sample Size: 414 *R^2: 0.495*		

Appendix N: Model Formulation

Accessibility Value for Service Area Zone i = w_1 (Average Patron Arrival Time Delay) + w_2 (Average Patron Pick Up Time Uncertainty) + w_3 (Average Patron Difference Between In Vehicle and Drive Alone Equivalent Travel Time) + w_4 (Percent of Unmet Demand in Service Area Zone i)/(Average Patron Arrival Time Delay)

Appendix O: List of Workshop Participants

The following participants attended the workshop on August 22, 2014.

Name	Agency	Attended via WebEx
Wade Odell	TxDOT – RTI	No
Lisa Loftus-Otway	CTR	No
Kari Banta	TxDOT – PTN	No
Tan Wang	CTR	No
Megan Hoklas	CTR	No
Robbie Silva	TCN Coastal Bend	Yes
Bob Schwab	El Paso Co	Yes
Melissa Cure	East Texas COG	Yes
Bob Johnson	Arlington	Yes
Alex Radke	Arlington	Yes
Bolivar Bolanos	TxDOT – PTN	Yes
Sebastian Astroza	CTR	No
Donna Roberts	TxDOT – PTN	Yes
Franki Martin	Presa Community Center	Yes