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16. Abstract
Demand Response Transit (DRT) is a critical form of transportation for handicapped, low income, and small/ medium sized communities. This type of service, which transports riders through an on-demand basis, is commonly used in communities that are not dense enough to support a fixed route transit system. Unfortunately, DRT systems face many challenges that restrict how well they can serve their community, including limited funding, understaffing, aging fleets, a lack of technical support, a lack of quantification of level of service standards, and limited modeling/planning practices. This report discusses the implementation of a unique DRT Accessibility Tool developed for the Texas Department of Transportation that addresses these challenges by determining how well a DRT system serves its riders and the most efficient ways to improve this service. The DRT Accessibility Tool, which is developed in Microsoft Access based on DRT travel logs, service characteristics and surveys from Brownsville, Texas, uses a system of models to simulate actual daily DRT travel patterns. Ultimately, DRT operators can use the Accessibility Tool in two robust ways. First, they can evaluate their current accessibility levels for various combinations of population groups, times of day, and travel purposes. Second, the Accessibility Tool allows operators to undertake "what if?" scenarios to evaluate changes in fleet characteristics (supply), population demographics (demand), and service areas (scope). Similarly, operators can predict (and anticipate) future needs of their riders by using the tool to analyze the impact of changes in population demographics. These results have the potential to inform important public transportation planning, budgetary, and policy decisions. This report summarizes the development and application of the DRT Accessibility Tool, including the motivation for creating the tool, the implementation workshops conducted throughout the research, the data and models that formulate the tool, a description of the user interface, and the ways the tool can be applied to evaluate and improve DRT service.

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DRT ACCESSIBILITY TOOL: SUMMARY REPORT

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INTRODUCTION

The DRT Accessibility Tool was developed to provide the Texas Department of Transportation (TxDOT) Public Transportation Division staff and transportation professionals within the state of Texas a tool to measure and benchmark accessibility for demand response transit (DRT) systems. The tool, formulated in Microsoft Access, uses a system of models to simulate actual daily DRT travel patterns for service regions and fleets of any size. In the end, transit system operators and planners have the option of measuring accessibility for various combinations of population groups, times of day, and travel purposes. The goal is to provide decision-makers with detailed information that will enable them to pinpoint areas where DRT service needs improvement or specific populations that need to be targeted.

The DRT Accessibility Tool is unique in that it evaluates the level of accessibility from the customer, or DRT patron, perspective rather than from an operational performance standpoint. While fleet size and efficiency are integral parts of DRT accessibility, ultimately the service must provide convenient connectivity between origins and destinations of interest to the patrons in order to be "accessible". As a result, accessibility is measured based on travel factors that are important to patrons, including travel time, drop off delay, pick up time uncertainty, and unmet demand.

This report summarizes the development and application of the DRT Accessibility Tool, including the motivation for creating the tool, the implementation workshops conducted throughout the research, the data and models that formulate the tool, a description of the user interface, and the ways the tool can be applied to evaluate and improve DRT service. For more detailed information regarding any of these topics, readers are encouraged to review the DRT Accessibility Tool User Guide document, available from the Texas Department of Transportation.

MOTIVATION

Demand response transit, also known as paratransit or dial-a-ride, is a critical form of transportation for mobility-impaired[1], low-income, elderly, and rural populations. This type of service, which transports riders through an on-demand basis, is commonly used in four main markets: 1) for the general public in rural areas that are not dense enough to support a fixed route transit system, 2) for the general public in urban areas acting independently of a fixed route transit system, 3) for the general public in urban areas as a feeder for a fixed route transit system, and 4) as ADA complementary services required by the 1991 Americans with Disabilities Act (ADA) (Spielberg and Pratt, 2004).

While similar scheduling practices are employed across all DRT operators (in which patrons call to schedule a trip and optimization software is used to determine each DRT vehicle's route for a given day), there are many variations of DRT service depending on the needs of the area. 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/destination, at convenient locations (including a fixed route bus stop),

[1] In this report, the term 'mobility-impaired' considers a range of special populations using transit, including wheelchair bound, blind, walking with an aid, and others.

or any combination of these (Kittelson & Associates, Inc., KFH Group, Inc., et al., 2003; Spielberg and Pratt, 2004).

All told, there were over 86.6 million unlinked DRT trips in 2005 (US Census Bureau, 2007). Yim and Khattak reported that over 370,000 vehicles and 22,884 private DRT system operators were serving these patrons in 1998 (2000). Regardless of their differences, all of these DRT system operators face similar challenges: they contend with limited funding, understaffing, aging fleets, a lack of technical support, no level of service standards, and few practical modeling/planning practices. These challenges are especially present in small and medium sized communities, where the largest percentages of residents rely on DRT service. In fact, over 21% of the United States' population currently resides in small and medium sized communities (Northeast Midwest Institute, 2002), and these numbers are projected to increase as such areas continue to develop as nationally critical economic centers (Cambridge Systematics, Inc. et al., 2008). As populations within such regions grow, these challenges will be amplified, potentially resulting in reduced mobility and stunted economic growth. Therefore, it is critically important that small and region communities take a proactive approach to transit planning.

Many of the current models of DRT best practices and customer/vehicle serviceability focus exclusively on operational improvements, such as fleet distribution, scheduling, and other supply-side factors (KFH Group, Inc. and A-M-M-A, 2001; KFH, 2002; Conklin et al., 2003; Sandlin and Anderson, 2004; Davenport, et al., 2005). This emphasis on operational improvements is partly due to the limited budgets and staffing of transit system operators in small and medium sized communities (Simon, 1998). But, it is also due to the fact that national funding and performance reviews are heavily based on these operational measures. However, DRT operations provide only half of the picture.

DRT system operators and community planners must also consider patron travel needs in order to completely assess the effectiveness of their transit program. Just because a DRT system operates cost-effectively does not automatically mean that all patrons are getting their preferred service. Fortunately, DRT patron-level performance measures, such as accessibility (defined as "the distance that people must travel to obtain goods, services, and participate in activities" (Victoria Transport Policy Institute, 2008)), on-time pickups, excessive travel times, arrival delays, and unmet demand (Easter Seals Project ACTION, 2002; KFH, 2008), have been receiving more attention recently. Regrettably, most work with these patron-level performance measures does not go beyond simple benchmarking (i.e. recording and comparing values over time). As a result, many of the reports that include patron-level measures are primarily concerned with identifying the most inexpensive, efficient, and effective methods for recording this information (Easter Seals Project ACTION, 2002; Potts and Marshall, 2007; KFH, 2008; Victoria Transport Policy Institute, 2008).

More important than benchmarking is the ability to evaluate and assess how specific changes in the DRT service region, population, and operations will affect these patron-level performance measures. Recently, a number of studies have emerged that attempt to accomplish this. Most notable is the field of forecasting, rural transit demand based on population characteristics, either through linear regression models, factoring methods, or other means (McIntyre et al., 1986; Schofer et al., 2003; Spielberg and Pratt, 2004; Koffman et al., 2007; Painter et al., 2007). Other studies develop methods for calculating typical travel characteristics for patrons based on distances between trip origins and destinations (Schofer et al., 2003), which can later be compared. Southworth et al. (2005) even distinguished differences in travel characteristics (i.e. costs, distance, time, safety, mobility) based on different trip purposes and available modes in his cost-benefit analysis tool. Such findings are extremely useful to DRT system operators in identifying ways for determining the most effective ways to improve service and patron travel satisfaction. Additionally, DRT system operators can invoke these measures when applying for funding based on improving DRT accessibility, such as the Rural Transportation Accessibility Incentive Program sponsored by the Federal Transit Administration (FTA) (US Department of Transportation, 2008).

The DRT Accessibility Tool presented in this report builds upon the previous work and presents a database tool that simulates DRT travel patterns to measure DRT patron accessibility. The DRT Accessibility Tool is unique because it adds both detailed spatial and individual patron elements to calculate accessibility for various types of individuals, times of day, trip purposes, and, most importantly, spatial areas. It not only considers DRT patron travel characteristics, but also how these characteristics are related to where DRT patrons specifically want to travel. As a result, system operators can determine the quality of DRT service across the service area and identify the most cost-effective ways to improve their service from a patron-perspective.

IMPLEMENTATION WORKSHOPS

The research team conducted four Texas implementation workshops during the process of developing the DRT Accessibility Tool – one each in Dallas (in November, 2006), Brownsville (in March, 2006), Tyler (in August, 2007), and San Angelo, (in September, 2007). At each location, the team met with Texas Department of Transportation (TxDOT) representatives and local transit system operators to present and discuss the fixed-route transit accessibility tool (created by the research team in a previous project) and the DRT Accessibility Tool (the topic of this report). In addition, the team toured demand response transit operation facilities and interviewed transit system operators regarding common operation and service concerns. The main goals of these workshops were to foster interest in applying these tools, to provide technical assistance, to answer questions, to discuss practical and meaningful applications, and to validate results.

The intent of the first implementation workshops was twofold: to present the fixed-route transit accessibility tool as well as to collect information from TxDOT and transit representatives that could be used to direct the formulation and development of the DRT Accessibility Tool. As a result, the team began these workshops by presenting and answering questions regarding the fixed-route transit accessibility tool. They then discussed the proposed DRT Accessibility Tool methodology, practical and meaningful applications of the tool, available data sources, and appropriate platforms for the tool. During these discussions, the team identified potential organizations with whom they could collaborate in developing and applying the DRT tool. In fact, during the second workshop in Brownsville, Texas, Brownsville Urban System offered to provide real-time spatial patron and travel data for the project.

By the time the team conducted later implementation workshops, much of the DRT Accessibility Tool had been developed (based on the information collected from TxDOT and transit representatives). Consequently, the main focus of these workshops was to present and improve the draft-form of the DRT Accessibility Tool, while still providing a summary of the fixed-route transit accessibility tool. The team discussed and received additional feedback from TxDOT and transit representatives about the steps involved in measuring DRT accessibility, data sources, functions and applications of the tool, the user-friendliness of the tool interface, and the appropriate markets for which to determine accessibility. From these discussions, the team was able to improve the DRT Accessibility Tool by reformatting the user interface, further defining aggregation schemes, and calculating economic comparison data for each accessibility measure. Additionally, the team was able to validate results by having local experts review preliminary accessibility results for each workshop region.

FORMULATION

The DRT Accessibility Tool was developed using a combination of spatial GIS data and actual recorded DRT patron trip data from Brownsville, TX. Brownsville is an ideal location for developing a tool to evaluate DRT accessibility because the Brownsville Urban System (BUS) transit provider is widely considered to be one of the most advanced DRT systems in Texas and the United States. In fact, in 2002, BUS served over 54 thousand passengers in its demand response transit services (US Census Bureau, 2007). Because the tool utilizes both spatial and trip data, users are able to evaluate DRT accessibility at the patron level and zone-based disaggregate scales (i.e. at the Traffic Analysis Zone (TAZ) or Census Block Group (CBG) level). Even though the data used in the tool is extremely detailed, the research team selected data sources that would be easy for transit system operators and planners to collect or replicate as well as be straightforward for nontechnical planners to implement. The spatial GIS data (which consisted of three main shapefiles, or digital map features, for roads, census block groups, and fixed-route transit routes) and patron trip data (which consisted of a detailed list of patrons as well as a complete log of all completed trips over an 8 month period) was formatted, cleaned, and merged. In this last step, patron home locations and trip 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.

Accessibility measures typically evaluate the number of travel opportunities and the ability to move between these travel opportunities (Hanson and Giuliano, 2004). In demand response transit, travel opportunities and characteristics change every day depending on where and when patrons request service, making the measurement of accessibility difficult. To accommodate for this, the DRT Accessibility Tool uses a system of models to simulate actual daily DRT travel patterns. The simulated travel characteristics are then used to measure DRT accessibility. The final task in formulating the DRT Accessibility Tool was to estimate these simulation models (described in the following section) from the spatial GIS and patron trip data collected from Brownsville, TX.

TOOL DESCRIPTION

The DRT Accessibility Tool is presented as an attractive, intuitive, and user-friendly Microsoft Access database package. This platform was primarily selected because it was already familiar to all the DRT system operators interviewed during this research, and it also allows the tool to be transferable, practical, and valuable for all communities. The tool is composed of three progressive tabs that users complete in order. In the first tab, entitled *DRT Service Characteristics*, users enter fleet and service area characteristics. Users have the option of entering the data for each vehicle and service area zone in this tab or by copying tables of data directly into the corresponding tables. In the second tab, entitled *DRT Travel Simulation*, users define simulation parameters and set the simulation to run. This tab features a status bar that indicates when each model is completed. In the third tab, entitled *DRT Accessibility*

Results, users clearly define how they want to measure accessibility, including the level of accessibility aggregation they want to measure. The tool is robust in that it allows users to measure accessibility for any combination of population groups, time of day, and trip purposes. This means that an operator can calculate accessibility from the general level all the way to any specific level of interest. The final results are queried based on the aggregation and presented in a pop-up table. This tab also features a list of economic details, such as operating costs, generated revenue, and total number of patrons served, that can be compared with the accessibility measure results.

The tool requires three tables of information in order to simulate and measure DRT accessibility. These tables include a service area characteristics table (which is comprised of population sociodemographics and land uses for every zone within the defined system), a fleet characteristics table (which is comprised of service information for every fleet vehicle), and a zone distance table (which is comprised of the straight line distances between every pair of zones). The contents of these tables and possible data sources are outlined in the following sections. The tool was designed with typical DRT system operators in mind and is flexible enough to allow for any fleet size or zoning scheme.

As mentioned previously, the tool uses service characteristics to simulate patron travel over a 24-hour period. The simulation uses a series of probability models, linear models, and discrete choice models to simulate DRT patron characteristics and decisions. These models were estimated using the actual DRT trip data collected from Brownsville, Texas. By the end of this simulation, the tool generates a table of patrons to be served, their demographics, origin and destination zones, trip purpose and time of day, travel characteristics, and whether they are able to be accommodated on a particular day or not. Users also have the option of running multiday simulations for higher precision—for more information regarding these models, please refer to the DRT Accessibility Tool User Guide document, available from the Texas Department of Transportation. The time it takes to run the DRT Accessibility Tool directly depends on the size of the service area used in the scenario. As a result, scenarios with larger service areas will take longer than scenarios with smaller service areas. For example, a typical service area within rural community or town of roughly 100 square miles will take about 15 minutes to run.

DRT accessibility results are based on aggregation schemes selected by the user. An accessibility value is calculated for each service area zone within the service region based on the following patron-level travel characteristics, developed from the literature review and a survey of DRT patrons in Tyler, Texas: the average number of minutes patrons from this census block group are arriving late at their destination (weighted 50%), the average number of minutes difference between when patrons from this census block group were scheduled to be picked up and when they actually got picked up (weighted 25%), 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 (weighted 15%), and the percent of the patrons from this zone that were not able to be scheduled during this period (weighted 10%).

These accessibility values are scaled so that each service area zone is assigned a final relative accessibility index value between 0 and 1, with 1 representing high accessibility. Users have the option of calculating a general accessibility measure across all patrons, times of day, and trip purposes within each service area zone or calculating a specific disaggregate accessibility measure for any combination of population groups, time of day, and trip purposes. For example, a user would be able to not only evaluate how accessible DRT generally is for patrons from each zone but also how accessible DRT is specifically for women going to work in the morning. If the user selects a specific disaggregate accessibility measure, the accessibility measure for each zone is averaged over only those patrons that meet the specific criteria (i.e. are women working in the morning).

APPLICATIONS

Over 21% of the United States' population currently resides in small and medium sized communities (Northeast Midwest Institute, 2002), and these numbers are projected to increase as such areas continue to develop as nationally critical economic centers (Cambridge Systematics, Inc. et al., 2008). Unfortunately, DRT transit systems already face many challenges that restrict how well they can serve their community, including limited funding, understaffing, aging fleets, a lack of technical support, a lack of quantification of level of service standards, and reduced modeling/planning practices. As rural populations grow, these challenges will be amplified, resulting in potentially reduced mobility and stunted economic growth. Therefore, it is critically important that DRT system operators take a proactive approach to transit planning. The DRT Accessibility Tool presented in this paper can be easily applied to DRT service regions of any size to assist transit system operators in these efforts. In fact, the tool is specifically designed around practitioner needs and expertise. System operators can use the tool for two main planning applications: First, they can evaluate their current accessibility levels for various combinations of population groups, service areas, and travel purposes. Second, the Accessibility Tool allows system operators to undertake "What If?" scenarios to evaluate changes in fleet characteristics (supply), population demographics (demand), and service areas (scope).

BENCHMARKING ACCESSIBILITY

The most straightforward implementation of the tool is to evaluate current accessibility level for various combinations of population groups, service areas, times of day, and travel purposes. Much of the previous literature is focused on methods for benchmarking current practices, and the tool provides detailed benchmarking measures of accessibility that can be compared over time. By using the tool in this capacity, system operators can study current service needs or evaluate accessibility trends over time. Furthermore, system operators can measure accessibility spatially on a regional scale or focus on specific population groups/times/trip purposes to identify areas that need more reliable service or specific population groups that need to be targeted. Figure 1 illustrates an application of the DRT Accessibility Tool to study general DRT accessibility in Brownsville, Texas. Each census block group has been assigned an accessibility index value that measures how well patrons from that block group are being served based on overall travel needs. These accessibility index values are ranked into four equal-sized groups (or quartiles) that represent the four levels of accessibility within the service region. The lightest census block groups are in the quartile identified as best serving patrons needs. As the census block groups coloring gets darker, their level of patron accessibility diminishes. In this example, DRT service provides the best accessibility for patrons living in the areas along the main highway corridor where street networks and land uses are more densely developed. System operators and planners can use maps such as this one to locate areas where DRT service may need to be improved or further studied. The ability to track benchmarks such as this will become increasingly important in the near future as funding relies more on these indicators.

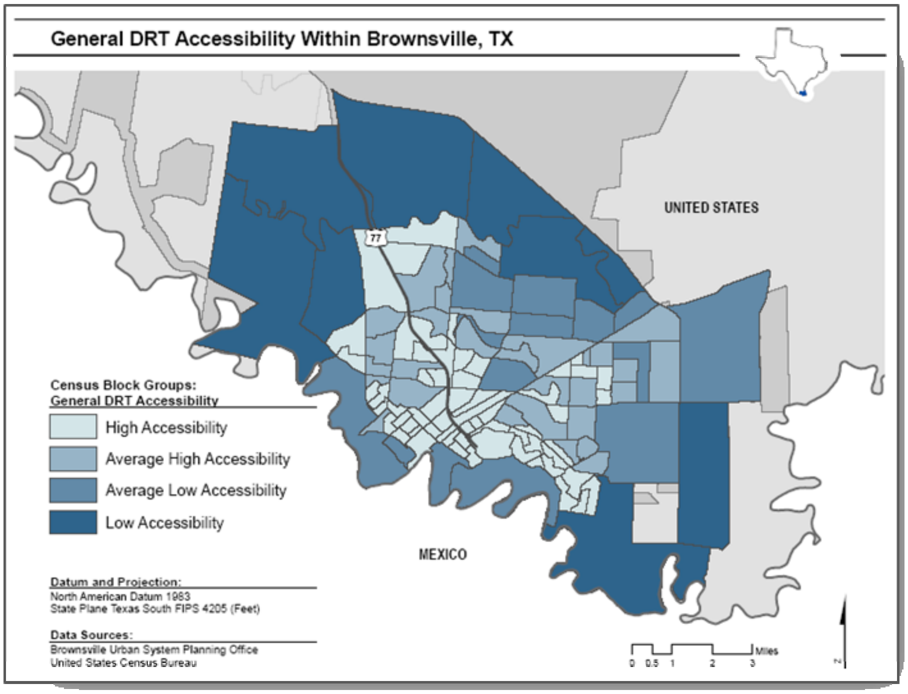


Figure 1: General DRT Accessibility within Brownsville, TX

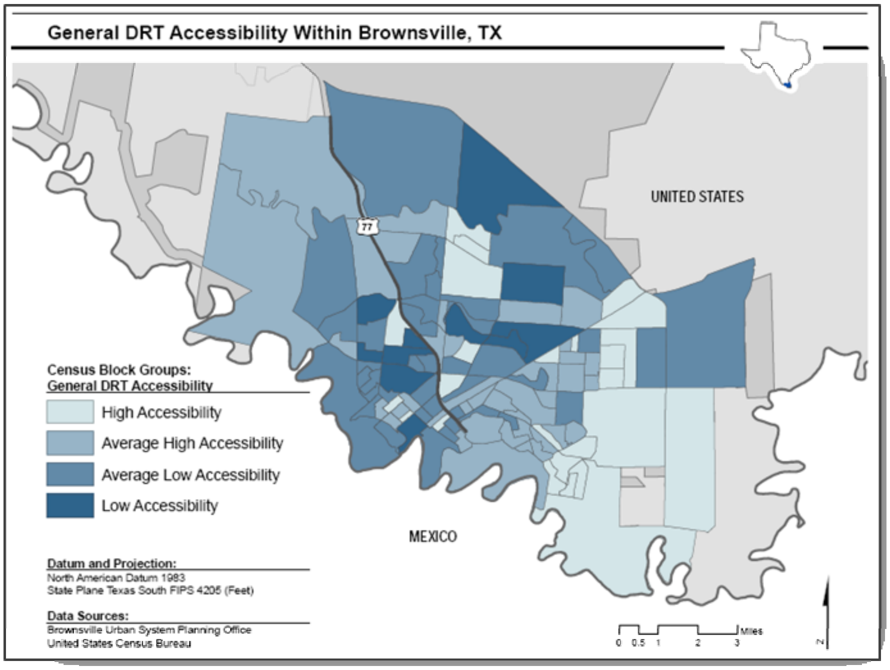
'WHAT IF?' SCENARIOS

More important, however, is the ability to conduct "What If?" scenarios to evaluate changes in fleet characteristics (supply), population demographics (demand), and service areas (scope). The tool allows an operator to calculate the impact of adding an additional vehicle or expanding the service region on patron DRT accessibility. Similarly, system operators can predict (and anticipate) future needs of their riders by using the tool to analyze changes in population demographics. System operators 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. For example, purchasing an additional wheelchair lift or ramp – equipped vehicle might be justified if mobility-impaired patron accessibility levels show a significant improvement with the addition of this vehicle. The tool provides many such robust opportunities for the planner to see how any changes may impact transit operation. These "What If?" scenarios will become increasingly important as these rural communities continue to develop.

To further assist system operators in evaluating "What If?" scenarios, the tool provides economic information related to each scenario. This information is calculated as part of the DRT travel simulation and offers context when reviewing the DRT accessibility results. When identifying the best alternative scenario, it is important to not only determine those scenarios that improve accessibility, but also those scenarios that are also economically feasible. For example, consider two scenarios that both improve overall patron accessibility roughly the same amount. However, based on the economic comparison, it is clear that one scenario increases operating costs, while the other scenario increases generated revenue. The second scenario should be the preferred alternative. This additional information, which includes timeframe, operating costs, generated revenue, percent of patrons served, size of the service area, and number of vehicles out of service, provides perspective and allows system operators to make more informed decisions regarding accessibility and changes in the system.

Figure 2 illustrates one such ‘What If?’ scenario: the impact that adding an additional vehicle to the fleet has on male DRT patron accessibility. In this example, adding an additional vehicle does not have a drastic impact on the entire service area zones’ accessibility for male patrons. However, a significant number of zones increased their average accessibility measures for male patrons. A few zones decreased in accessibility as well, but since the accessibility measures are relative indices, there will always be a slight downward shift of accessibility in some zones down to balance out the upward shift of accessibility in other zones. In instances like this, though, the additional capacity had an overall positive effect as seen by the fact that the number of upward shifts significantly outweighs the number of downward shifts. Users could continue the ‘What If?’ analysis by adding additional vehicles until there was little or no change to the accessibility measures. In doing this, system operators could identify the fleet size limit to which no more vehicles would improve accessibility. System operators could also conduct a similar ‘What If?’ analysis to determine the impact improved vehicle efficiency would have on male DRT patron accessibility. After identifying the most efficient scenario, they could then compare the economic factors for the increased fleet size and improved efficiency alternatives to find the best option. The Tool can conduct any possible ‘What If?’ scenarios system operators and planners would need.

The DRT Accessibility Tool is, as the name states, a *tool* that DRT system operators can work with to improve their transit planning and DRT patron accessibility, rather than an independent program that ‘spits out’ generic results. Because of this, system operators will be able to apply their knowledge of the service region, their patrons, and operations with the Tool to arrive at solutions that are meaningful and specific to their area. However, system operators should keep in mind the particulars of a tool such as this that calculates accessibility for each zone relative to the other zones within the service region. While this method allows system operators to identify those zones that stand out with relatively high and low accessibility, system operators will not be able to compare accessibility indices of two different service regions unless they evaluate both at the same time. This also means that there will always be zones with a relative high and low accessibility measures, although the difference may be only minor, regardless of any changes made to the system.



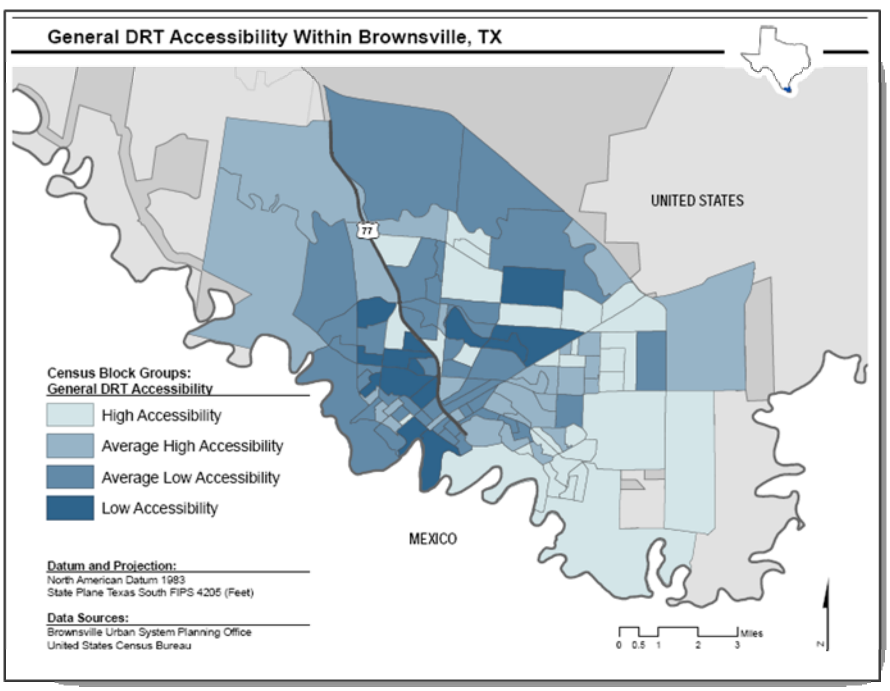


Figure 2: General Male DRT Accessibility within Brownsville, TX
Before and After Adding an Additional Fleet Vehicle

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