

Development of an Urban Accessibility Index: A Summary

PROJECT SUMMARY REPORT

In the face of rising traffic volumes, decreasing open space, increasing air pollution, and reduced funding, transportation planners are looking for responsive and accurate ways to evaluate the effectiveness of alternative transportation projects. Specifically, they are seeking additional information when prioritizing transportation projects and when working toward the equitable distribution of limited resources.

The overall goal of this project was to develop a measure of urban accessibility that reflects the extent of interaction and compatibility between an urban area's land development patterns and its transportation infrastructure. This urban accessibility can be used to identify areas with low accessibility and to prioritize alternative projects and policies. In addition, the measure is intended to provide accessibility information specific to multiple levels of spatial interest, travel modes, activity purposes, and times of day.

What We Did...

Choosing a Measure

Traditional measures of the effectiveness of the transportation system assess mobility. The challenge of accessibility measures is to characterize, in a meaningful way, the overall

system represented by the interaction between land use patterns and transportation facilities. The land use part of the system represents the opportunities for activity participation, while the transportation part of the system represents the ease of participating in activities at specific locations.

In this research, we considered five main types of accessibility measures, and all of these were evaluated against several criteria developed in the research. The simplest type of accessibility measure is the spatial separation, or graph theory, measure. This type of measure relies solely on information related to the transportation system and therefore was not considered for further evaluation. A second type of accessibility measure is the cumulative opportunities measure that provides a counting of opportunities available within a certain distance or travel time. A third type of accessibility measure is the gravity measure. This type of measure also counts opportunities; however, the value of an opportunity decreases with increasing distance. Using traveler destination choice data, local parameters can be computed to reflect the attractiveness of activity opportunities and the decrease in attractiveness based on the distance of the opportuni-

ty. The fourth type of accessibility measure, the maximum-utility, or logsum, measure, shares many features with the gravity measures. However, it derives from discrete choice models of travel choice and corresponds to the natural logarithm of the denominator of the multinomial logit mode choice model used in travel demand forecasting. It is straightforward to show that the gravity measures can be derived from the concept of utility, and thus, the third and fourth types of measures are essentially equivalent. Last, the fifth type of accessibility measure considered in this work is the time-space measure of accessibility. This type of measure includes detailed information such as the hours of operation of activity opportunities. Because of the data requirements for this type of measure, it was not considered for further evaluation in this study.

In the current research, several versions of the cumulative opportunities (second type) and gravity/utility measures (third and fourth types) were evaluated using data from the Dallas/Fort Worth region. The evaluation of the different types of measures was based on theory, the ability to differentiate between different kinds of regions (urban, suburban, rural, and downtown), the ability to differentiate between



areas with different incomes, and the overall performance of each type of measure.

Choosing an Aggregation Method

Since the goal of this research was the development of a measure that could be aggregated along several dimensions, the issue of aggregation was investigated systematically and thoroughly. Various researchers have explored methods of aggregation along individual dimensions. However, none of these methods is suitable for aggregation along the multiple dimensions proposed in this research. The current research formulates an aggregation method to characterize accessibility that is theoretically consistent at all levels of aggregation, while at the same time being easy to implement using readily available data.

Aggregation and Implementation

After an accessibility measure was chosen and an aggregation method developed, the process of computing accessibility at the disaggregate and aggregate levels was operationalized using a computer program with a user-friendly interface. Designed to run as a macro in TransCAD, the Accessibility Add-In to TransCAD allows the user to compute accessibility at a variety of levels of aggregation using either datasets that come with the software package or user-provided data prepared as instructed in the manual. The built-in data sets are for the Dallas/Fort Worth area and the Austin area. The output from the Add-In module is a regular TransCAD layer of accessibility values that can be manipulated like any other TransCAD data file. Besides computing the accessibility for a given scenario of land-use and transportation, the software also has the capability of computing the *difference* in accessibility measures because of a change to the land-use system or the transportation system or both.

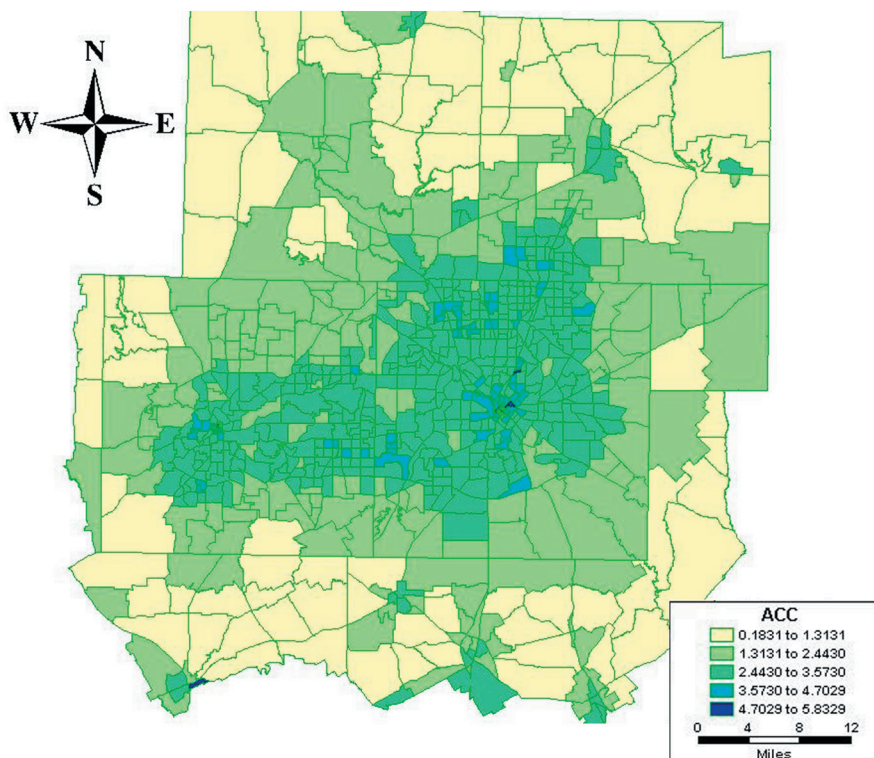


Figure One: Map of Dallas-Fort Worth Metropolitan Area with Accessibility Values for Work Trips Using the Highway Mode at Peak Travel Time

What We Found...

Evaluating Accessibility Measures

Six different accessibility measures were evaluated for use in the development of the urban accessibility index. Two of the measures corresponded to cumulative opportunities measures that used two different threshold travel times to compute the opportunities for activity participation. A Gaussian form (a normal distribution) of the gravity measure was also evaluated. This form of the measure gives high value to opportunities near the source of measurement. At some distance from the origin, it begins to substantially discount opportunities. The average travel time for each trip purpose in the study region was used as the point of inflection in the Gaussian curve.

Three other gravity/utility measures were also evaluated. One measure used travel time as the measure

of impedance, one used distance, and another used a composite travel impedance measure that allowed for the inclusion of travel costs and travel times. All of these measures included parameters reflecting the attractiveness of activity opportunities and the decrease in attractiveness based on distance of the opportunity.

Based on our criteria for an acceptable accessibility measure, we chose a gravity/utility measure that uses a composite form of travel impedance. The cumulative opportunities measures were found to be weak on theoretical grounds. By equally valuing every opportunity in the isochrone (a contour line on a map of constant travel time), there was no acknowledgement of the higher time or money cost in pursuing distant activity opportunities. They were also found to be relatively poor in their ability to reflect local peaking in the smaller communities outside the main metropolitan areas of Dal-



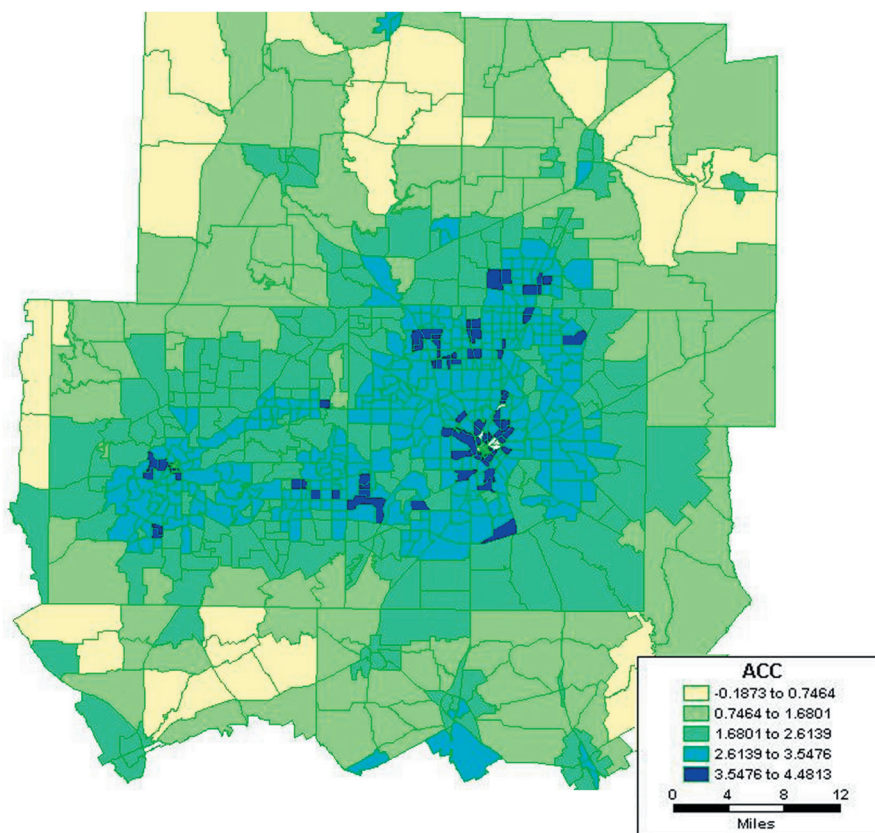


Figure One: Map of Dallas-Fort Worth Metropolitan Area with Accessibility Values for Social Recreation Trips Using the Highway Mode at Peak Travel Time

las and Fort Worth.

The chosen measure was then used to evaluate accessibility to various destinations in the Dallas/Fort Worth area. Using the TransCAD macro developed through this research, we were able to prepare several maps giving a visual representation of accessibility. Figure 1 presents our results for accessibility to work. The downtown areas, where the most people work and that are well-served by the highway system, have relatively high levels of accessibility. The outlying areas have relatively low accessibility. However, the smaller city centers do show locally high accessibility compared to the surrounding area.

Since quality of life is increasingly cited as a concern for people, Figure 2 presents accessibility to social-recreation activities. Parkland is used as the proxy for opportunities to participate in social-recreational

activities. As expected, the parks and lake areas of the region now indicate relatively high accessibility compared to other areas. The high connectivity via the highway system is reflected in the relatively high accessibility of the downtown areas.

The Researchers Recommend...

Recommendations based on this research fall into two main categories: implementation and further research.

Implementation Recommendations

The next step for the software program is to apply it to metropolitan areas to evaluate alternative land-use and transportation options being considered in the area. Such an application will allow policy-makers to make informed decisions on future investments. The product

developed here allows for the consideration of multiple modes.

Second, the default data and model parameters used to compute accessibility in the software package needs to be expanded. The addition of a city such as Tyler would expand the choices of the software to include small, medium, and large Texas cities. A range of choices for areas without the need for extensive calculation of local parameters will facilitate the widespread application of the software tool.

Research Recommendations

There are at least two aspects of the aggregation methodology that warrant further investigation. First is the comparison of the different levels of aggregation. With the four dimensions of spatial unit, trip purpose, time of day, and mode, there are sixteen possible aggregation configurations. Although all these aggregation levels can be calculated, some may be more useful for transportation planning analysis than others.

Second, the current software focuses only on the internal accessibility of an urban region without any consideration of how well the urban region is connected externally to other urban regions. Including this aspect of accessibility will facilitate a comprehensive evaluation of both the internal and external accessibility of an urban region.



For More Details...

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The research is documented in the following reports:

- 4938-1 *Development of an Urban Accessibility Index: Literature Review*, May 2000
- 4938-2 *Accessibility Measures: Formulation Considerations and Current Applications*, September 2000
- 4938-3 *Assessment of Accessibility Measures*, August 2001
- 4938-4 *Development of an Urban Accessibility Index: Formulations, Aggregation, and Application*, October 2002

**To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3138, email: ctrlib@uts.cc.utexas.edu**

TxDOT Implementation Status March 2003

The research product is a menu-driven TRANSCAD program and user guide for calculating the urban accessibility index/indices. The program and user guide has been turned over to TxDOT's Transportation Planning and Programming Division for possible trial use.

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Your Involvement Is Welcome!

Disclaimer

This research was performed in cooperation with the Texas Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration. The content of this report reflects the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The engineer in charge was Chandra Bhat (Texas No. 88971).



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