

Technical Report Documentation Page

1. Report No. FHWA/TX-02-4938-4	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle  DEVELOPMENT OF AN URBAN ACCESSIBILITY INDEX: FORMULATIONS, AGGREGATION, AND APPLICATION		5. Report Date  October 2002	
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		8. Performing Organization Report No. 4938-4	
9. Performing Organization Name and Address Center for Transportation Research The University of Texas at Austin 3208 Red River, Suite 200 Austin, TX 78705-2650		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No. Project 7-4938	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, TX 78763-5080		13. Type of Report and Period Covered Research Report (9/99 – 10/02)	
		14. Sponsoring Agency Code	
15. Supplementary Notes Project conducted in cooperation with the Texas Department of Transportation, U.S. Department of Transportation, Federal Highway Administration.			
16. Abstract This is the final report for the research project: Development of an Urban Accessibility Index. The objective was to select an accessibility measure and develop a methodology to aggregate/disaggregate accessibility measures along several dimensions of interest: time of day, mode, trip purpose, and space. The main types of accessibility measures are presented and assessed for their relevance for the research objective. A gravity/logsum measure is chosen. Aggregation along individual dimensions are assessed for use in this research. Ultimately a method based on the multinomial logit model is developed for use. The accessibility measure and aggregation method are then coded in an add-in for use with the TransCAD GIS system. The software program comes with the Dallas/Fort Worth and Austin data sets. However, data from any area can be used. Outputs from the software include a color-coded map indicating areas of relatively high and low accessibility and a table that can be manipulated in the same way as any other GIS layer. The User's Manual for the software is included as an appendix.			
17. Key Words Accessibility, Aggregation	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.		
19. Security Classif. (of report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages 176	22. Price



# Development of an Urban Accessibility Index: Formulations, Aggregation, and Application

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Research Report Number 4938-4

Research Project 7-4938  
*Development of an Urban Accessibility Index*

Conducted for the  
Texas Department of Transportation  
in cooperation with the  
U.S. Department of Transportation  
Federal Highway Administration  
by the  
Center for Transportation Research  
Bureau of Engineering Research  
The University of Texas at Austin  
October 2002



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## **Acknowledgments**

Appreciation is expressed to Jack Foster, TxDOT project director, for his support of this project.

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.



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# 1. Introduction

In the face of rising traffic volume, 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. In order to address these concerns, transportation planners are looking to measures that go beyond the traditional category of mobility measures. Mobility measures concentrate on the ease of movement. Some of the measures under consideration attempt to evaluate the transportation and land use system from the user's perspective. Measures that include information about both transportation and land use falls into the general category of accessibility measures. These measures assess the ease of interaction and go beyond mobility measures in their ability to represent both land use and the transportation system aspects of an area.

The accessibility measure presented here is intended to be used in statewide transportation planning, as well as other planning efforts, for two specific purposes. First, as a measure of the current conditions in an area. Second, as an alternate method to evaluate conditions before and after project implementation.

While many accessibility measures provide information at a disaggregate level (at a particular time of day for a particular mode and trip purpose), a key innovation in the work presented here is the ability to aggregate over any combination of four dimensions. The four dimensions are: trip purpose, mode, time-of-day, and spatial level.

For several decades now, accessibility has been the focus of literature in various fields of study. This undoubtedly reflects the different study purposes for which any particular measure may have been proposed. However, there does not appear to be a common definition of "accessibility." Some researchers discuss accessibility "to" some place (or places) as opposed to accessibility "from" some place (or places). Some researchers characterize accessibility as a measure of the transportation system from the perspective of users of that system (Ikhata and Michell 1997). In this project, we use the following, qualitative definition: accessibility is a measure of the ease with which an individual can pursue an activity of a desired type, at a desired location, by a desired mode, and at a desired time.

Once accessibility can be quantified, there are many potential uses for this measure. First, it succinctly captures the quality of the existing state of the transportation system at many

spatial levels. This allows for the identification of areas with relatively low accessibility, and provides a basis for developing transportation and land use proposals. Second, it provides an estimation of impacts due to proposed changes in the transportation system. Because of the multi-dimensional character of this measure, it could assess changes to both road building and transit improvements. Third, it tracks and monitors changes in accessibility due to shifts in the distribution of land uses and can aid evaluation of the impact of alternative land use policies, such as the promotion of infill. Fourth, dimension-specific accessibility indices provide information for policy makers to more effectively target investments for specific dimensions. For example, improving accessibility to recreation or shopping, or improving access at a particular time of day, or for a specific mode.

The measure developed here can provide relevant information for a variety of applications. Although developed for statewide transportation planning, this measure can be used in other areas of transportation planning. For example, at the regional level this measure could be used in Environmental Impact Studies. It could highlight potentially disproportionate impacts of a project. At the level of the metropolitan planning organization this could be part of long-range planning efforts. In cities this measure could be used in the comprehensive planning process and for corridor planning.

In addition, an accessibility measure can be used by individual households and businesses as a quality-of-life index when making relocation decisions. It may function as a land use/transportation version of a cost-of-living index.

Several areas in the United States and Europe have incorporated accessibility measures into their transportation planning process. In the United States environmental justice and transportation equity are typically two forces driving the inclusion of accessibility measures in transportation performance analysis (FHWAa). Areas such as the state of Florida, Columbus, Ohio, and Orange County, California are using accessibility measures. The aim of the Florida accessibility measure is to assess the ease with which people can access the transportation system (FHWAa). In an effort to specifically address issues related to environmental justice, Columbus, Ohio has developed several measures. The transportation-related measures are designed to characterize access to jobs by members of the target populations (FHWA b). And, in Orange County, California access to bus stops is the focus of their accessibility measures (FHWAa).

These are a few examples of the use of accessibility measures in the United States as an alternative to traditional performance measures in transportation planning.

In the United Kingdom the use of accessibility in the analysis of transportation projects is mandated at the federal level as part of the nation's sustainability efforts (Hardcastle and Cleeve 1995). There is, however, no guidance regarding the formulation of the accessibility measure. Other countries such as the Netherlands (Hilbers and Verroen 1993) and Spain (Echeverría Jdraque et al. 1996) continue to explore the inclusion of accessibility measures in urban transportation analyses.

Chapter 2 of this report presents information about accessibility measures in general. It covers the desirable characteristics of an accessibility measure, presents the conventional forms of accessibility measures, discusses data needs and availability, and concludes with the selection process of a specific measure as undertaken in this project. Chapter 3 discusses aggregation of accessibility measures across the dimensions of interest. It summarizes methodologies used for aggregation across a single dimension (such as space or trip purpose) and then presents a technique that can be used across multiple dimensions. Chapter 4 presents the design details of the software produced to calculate accessibility at various levels of aggregation. The User's Guide for this software is attached as Appendix B. Chapter 5 provides some concluding thoughts for this research project and describes future extensions of this work.



## **2. Accessibility: Forms and the Choice of a Measure**

Traditionally, measures used to evaluate the transportation system have focused on the concept of mobility. Mobility measures assess the potential for movement. They typically include elements that describe level of service, road capacity, and design speed.

On the other hand, accessibility measures assess the potential for interaction. Elements of an accessibility measure would describe the spatial distribution of destinations, the ease of reaching those destinations, and the quality of the destinations. Mobility is one element of accessibility. A typical accessibility measure has two components. One is related to the destinations and is commonly called the attractions portion of the measure. Typical attractions measures for shopping include: number of employees, amount of sales, or square feet of space. The second component describes the ease of reaching those attractions. Since difficulty increases over distance this component is commonly called the impedance factor. Typical impedance factors include: the distance to the attraction, the amount of time it takes to reach the attraction, or the cost of traveling to the attraction. A third type of information that some researchers have included in their computation of accessibility is data about the user group of interest (Breheny 1978, Helling 1998, Mowforth 1989, Wachs and Kumagi 1973). These data are not included in the measure. Instead it is used to select attractions and impedance data to be included in the calculation of the accessibility measure. Aspects of interest may be gender (Hanson and Schwab 1987), race (Helling 1998), or income (Wachs and Kumagi 1973).

Accessibility has been a part of transportation policy discussions, but is not a part of traditional transportation models; consequently, it lacks a formal definition. Responsiveness to changes in land use patterns and the transportation system is at the heart of the mobility-versus-accessibility discussion.

Bach (1981) posits that there are several issues to resolve related to not having a universal definition of accessibility. One is the notion of accessibility “from” versus accessibility “to.” With a measure that includes both land use and the transportation system, the use is an integral part of the measure. A household is potentially interested in accessibility from their home. How accessible are shopping and recreation opportunities from their home? A business owner is potentially interested in accessibility to his or her business. How accessible is the business to potential patrons? Another issue discussed in the earlier literature has to do with

relative accessibility (accessibility between two points) compared to integral accessibility (accessibility between one point and all the other points in an area) (Ingram 1971). Today this is resolved via aggregation techniques. Knox (1978) argues that it is not the accessibility of places that needs to be measured, but the accessibility per person in a zone.

Pirie (1979) argues that one purpose for developing such measures is to maintain a certain level of accessibility for citizens. These measures would reflect people interacting with the built environment. They also would identify social inequities (Wachs and Kumagi 1973). Similarly, several researchers propose using an accessibility measure to highlight the need for changes in the transportation system or land use patterns. For this purpose, Davidson (c. 1980) develops an inverse accessibility measure that he calls 'isolation.' Researchers have also debated the form of an accessibility measure. One uses a desired minimum standard to identify areas below standard (Wickstrom 1971). Another researcher proposes scaling all accessibility measures in an area to the highest value (Knox 1978). Several authors maintain that the purpose of the accessibility measure should dictate the form (Handy 1993, Verroen and Hilbers c. 1996).

## **Section 2.1 Characteristics of an Accessibility Measure for General Use**

After studying the gamut of accessibility measures, several researchers have proposed basic criteria that need to be addressed by any accessibility measure (Pirie 1979, Bach 1981, Weibull 1976, Weibull 1980, Morris et al. 1979). Because accessibility is a combination of the transportation system and land use patterns, many agree that any measure should respond to changes in either, or both, of these elements (Morris et al. 1979, Voges and Naudé 1983, Handy and Niemeier 1997, McKenzie c. 1984, Zakaria 1974).

Weibull (1976) developed several axioms for the form of an accessibility measure. Many researchers adhere to these basic criteria (Koenig 1980, Miller 1999, Tagore and Sikdar 1996). These are: the order of opportunities should not affect the value of the measure (the structure of the data should not influence the results); the measure should not increase with increasing distances or decrease with increasing attractions (this incorporates the microeconomic basis of travel behavior that attractions have utility and travel has disutility); and opportunities with zero value should not contribute to the measure.

Morris et al. (1979) propose several other criteria. They are related to the parameters and performance of an accessibility measure. Their criteria are:

- a measure should have a behavioral basis;
- it should be technically feasible; and
- it should be easy to interpret.

The first criterion suggests the need to incorporate social-demographic factors that may influence activity participation. However, researchers don't necessarily agree as to what the behavioral basis should be. For example, several researchers (Pirie 1979, Breheny 1978, Handy and Niemeier 1997, McKenzie c. 1984) argue that observed behavior is not necessarily an indicator of preferred behavior. The second criterion presages today's performance measures. It highlights the real-world application of accessibility measures developed in the academic literature. In addition, researchers call for the use of data already gathered to increase feasibility. Lastly, having a measure that is easy to interpret facilitates policy-making and public involvement.

Others have proposed additional criteria. Davidson (1977) indicates that accessibility should increase as another mode is added to an area, and conversely not decrease the accessibility of the original modes. A measure should explicitly acknowledge the addition of a new mode to the choice set. Voges and Naudé (1983) argue that disaggregation is an important quality of accessibility measures that allows evaluation along several different dimensions.

Before an accessibility measure is planned, Wilson (1971) proposes several questions that need to be answered. These are:

- what is the degree and type of disaggregation desired;
- how are origins and destinations defined;
- how is attraction measured; and
- how is impedance measured?

This last point is an important characterization of a measure. A distance measure does not account for level of service and a time measure is time-of-day dependent. Regarding cost of travel, Savigear (1967) suggests that parking availability should be a consideration when trying to determine accessibility to places—particularly central business districts (CBD). There is, however, no straightforward answer to this question, and the following chapters include researchers' resolutions to this issue.

Besides the specific criteria outlined above, researchers investigated other parameters potentially affecting an accessibility measure. Bach (1981) assessed to what extent different

ways of measuring separation and different levels of aggregation influence a measure's value. In terms of trading off exactness and efficiency, Bach concludes that cities today generally have information available at a zonal level that is appropriate for determining the placement of public facilities (libraries, post offices, swimming pools, etc.). He still cautions that level of aggregation should be considered when trying to measure the accessibility of a location, because the level of aggregation can change but the location of the point in question is constant.

Also affecting the parameters of an accessibility measure is the difference between perceived and objective accessibility (Pirie 1979, Morris et al. 1979). Wilson (1971) argues that impedance factors need to be weighted to reflect individuals' perceptions. Davidson (c. 1980) also argues in favor of the use of perceived distances as the most accurate way to measure accessibility. However, construction of perceived accessibility measures requires subjective data, and applications of such measures are more difficult from a data standpoint than using objective parameters in the accessibility measure.

## **Section 2.2 Conventional Forms of Accessibility Measures**

During the past several decades of research regarding accessibility, five main types of measures have emerged. Each type of measure highlights a different way to characterize the interaction between the transportation system and land use as well as a range of complexity. These measures are discussed in more detail in the first research report in this series (Bhat et al. 2000a). Below is a brief description of the main characteristics of the five types of measures.

### *Spatial Separation*

The simplest accessibility measure is the distance or separation measure. The only dimension used is distance. Because these measures do not consider attraction level (e.g., land use), strictly speaking they do not fit the general definition of an accessibility measure discussed above. But, they are more than a mobility measure because they discount distances. The most general network accessibility measure consists of the weighted average of the travel times to all the other zones under consideration. Equation 2.1 is a general version of this type of measure.

$$A_i = \frac{\sum_j d_{ij}}{b} \quad (\text{Eq. 2.1})$$

In this general formulation of this version of an accessibility measure,  $d_{ij}$  is the distance between zones  $i$  and  $j$ , and  $b$  is a general parameter. Early work in the graph theory area used a

completely abstract version of the road network (Baxter and Lenzi 1975, Kirby 1976). There were two reasons for this: one was the cost of analysis at that time, and the other was the argument that the measure should be compared to the ideal of the Euclidean distance between two areas.

If accessibility is an indication of the combination of land use and the transportation system, then criticism of the spatial separation measure's lack of land use information is well-founded (Voges and Naudé 1983). Another criticism of such measures is their reflexive nature (Pirie 1979). Accessibility from point A to point B is the same as from point B to point A, which indicates independence from land use information. Nor does it reflect theories of travel behavior.

### *Cumulative Opportunities*

The simplest accessibility measure that takes account of both distance and the objective of a trip is the cumulative-opportunities measure. This measure defines a travel time or distance threshold and uses the number of potential activities within that threshold as the accessibility for that spatial unit.

$$A_i = \sum_j O_{jt} \quad (\text{Eq. 2.2})$$

Here  $t$  is the threshold, and  $O_{jt}$  is an opportunity that can be reached within that threshold. Often, several time or distance increments are used to create an isochronic map (Hanson 1986, Hardcastle and Cleeve 1995). The only information needed for this measure is the location of all the destinations (e.g., jobs or hospitals) within the desired threshold. An argument for this method is that it bypasses the zonal aggregation problem of other methods (Wachs and Kumagi 1973, Hanson and Schwab 1987). Because attractions are counted individually, there is no loss of information due to averaging.

The main criticism of the cumulative-opportunities measure is that there is no behavioral dimension, and near and far opportunities are treated equally (Voges and Naudé 1983). Weibull (1976) addresses the former issue by including a parameter related to car ownership and Handy (1992) addresses both issues with her distance-decay weighted count, and calibration to observed travel choices.

### *Gravity Measures*

In 1956 Carrothers discussed the use of physical mathematical relationships that could be applied to relationships between cities—specifically the gravity model of interaction. This well-researched paper includes a phrase often found in accessibility literature—the “possibility of interaction.” His paper discusses an attracting force and the friction of intervening space. There are earlier applications of gravity equations to sociological situations dating from the 1930s. But Hansen (1959) is the author generally credited with the earliest application of the gravity model to accessibility.

The gravity measure includes an attraction factor as well as a separation factor. While the cumulative-opportunities measure uses a discrete measure of time or distance and then counts up attractions, gravity-based measures use a continuous measure that is then used to discount opportunities with increasing time or distance from the origin. The general form of the model has an attraction factor weighted by the travel time or distance raised to some exponent.

$$A_i = \sum_j \frac{O_j}{t_{ij}^\alpha} \quad (\text{Eq. 2.3})$$

Data requirements for this measure are the size and placement of the attractions under investigation and the travel time or distance between zones in the study area. The attractions element of the gravity measure reflects the amount of activity in a zone, as opposed to the simple enumeration of the cumulative opportunities measure. Where a cumulative opportunities measure might count number of grocery stores, a gravity measure might use the total retail floor area of grocery stores in a zone as a measure of attraction.

The cumulative-opportunities model is criticized for treating opportunities equally, whether they are right at the origin of study or just inside the isochronic line determined by the time or distance parameter (although Weibull [1976] and Handy [1992] mitigate for this effect). Including the time or distance in the denominator of the equation, gravity-type measures provide a dampening effect that devalues attractions far from the origin.

Many researchers have explored the appropriate nature of the impedance factor of the gravity equation. Some argue for a Gaussian form that values nearby attractions highly and then falls off more quickly with distance or time. Searching for an appropriate form and value of the impedance function, many researchers find it appropriate to have different parameter values for different kinds of attractions. An example often cited is that many individuals are willing to

travel farther for work than for other activities. Handy (1992) empirically found a higher parameter for convenience shopping than comparison shopping.

Several researchers criticize the ability of gravity-based accessibility measures to accurately reflect accessibility. Many measures assign the same level of accessibility to all individuals in a zone; however, this does not reflect the possibility that two people in the same place may face different levels of accessibility. (Ben-Akiva and Lerman 1979, Handy and Niemeier 1997)

Another point of criticism is the practice of calibrating a model with data from one locality and then applying it in a different area. As mentioned earlier, several researchers found local data useful in calibrating their measures. However, transference is not uncommon in other transportation-modeling situations. Agyemang-Duah and Hall (1997) were successful in transferring an ordered-response model to other areas that needed limited changes to the model parameters. Their model includes a gravity-based accessibility measure as one of the variables. They found this method works reasonably well.

A final criticism is that the general form of the gravity model implies a trade-off between attraction and distance. One unit of attraction is equal to one unit of distance (Whitbread as quoted in Morris et al. 1979). One way that researchers address this is by including an exponent to the attractions component (as well as the travel component) of the measure (Guo and Bhat 2001). The value of this exponent is derived from local data.

### *Utility Measures*

Another approach to measure accessibility is with a utility-based measure. This type of measure is based on an individual's perceived utility for different travel choices.

The most general form of this measure is:

$$A_n = E \left[ \underset{i \in C}{\text{Max}} U_{in} \right] = \ln \sum_{i \in C} \exp(V_{in}) \quad (\text{Eq. 2.4})$$

The method of calculating accessibility for an individual  $n$ , is the expected value of the maximum of the utilities ( $U_{in}$ ) over all alternative spatial destinations  $i$  in choice set  $C$ . The utility is determined by taking the logsum of  $V_{in}$ . This is a linear function with elements representing factors related to accessibility such as the quality of the attraction and the travel

costs associated with reaching that attraction. The utility measure is also known as the logsum of the discrete choice model.

Ben-Akiva and Lerman (1979) prove that the utility form of accessibility meets several criteria described by Weibull (1980). For example, it:

- does not decrease with the addition of alternatives; and
- does not decrease if the mean of any one choice utility increases.

Ben-Akiva and Lerman (1979) point out that because the above expression is the natural logarithm of the denominator of the multinomial logit mode choice model used in travel demand forecasting, it is often available with very little extra computation.

One criticism of the utility/logsum approach to measuring accessibility is that not all options are available to all individuals, and there are no natural constraints for the choice set (Ben-Akiva and Lerman 1979). Similarly, researchers need to be aware of including irrelevant alternatives in the choice set and the consequences thereof, such as decreasing the probability of viable choices (Ben-Akiva and Lerman 1979). And, an accessibility measure based on utility will only reflect observed behavior and not reflect the benefit of increased choices (Morris et al. 1979).

### *Time-Space Measures*

Time-space measures add another dimension to the conceptual framework of accessibility corresponding to the time constraints of individuals under consideration. Early work in this area was conducted in Sweden by Hägerstrand (1970). He used a three-dimensional prism of the space and time available to an individual for partaking in activities.

The motivation behind this approach to accessibility is that individuals have only limited time periods during which to undertake activities. As travel times increase, the size of their prisms shrink. The space dimension of this measure is calculated with the accessibility measures described in the previous chapters. Constraints on time are generally divided into three classes (Hägerstrand 1970):

- capability constraints — related to the limits of human performance (e.g., people need to sleep every day);
- coupling constraints — when an individual needs to be at a particular location at a particular time (e.g., work); and

- authority constraints — higher authorities that inhibit movement or activities (e.g., park curfews).

In recognizing the time-space accessibility of individuals, trip chaining can be better evaluated (Wang and Timmermans 1996). This approach follows a trend in trip modeling today, where modelers emphasize trip-activity packages, and not just single trips (Van der Hoorn 1983, Bhat and Koppelman 1993, Bowman and Ben-Akiva 2000). Another consequence of modeling accessibility of individuals is the ability to distinguish different members of the same household who may face different levels of accessibility (Kwan 1998).

Results of this measure can be presented graphically with the choices available to an individual represented by an area that meets certain criteria calculated by other accessibility measures (e.g., meeting a certain level of utility, encompassing a certain number of attractions) (Miller 1999).

The main criticism of space-time measures is that due to a high level of disaggregation they are difficult to aggregate (Voges and Naudé 1983, Miller 1999), and it is difficult to look at the effects of changes on the larger scale such as in land use and the transportation system (Voges and Naudé 1983, Burns 1979). For example, a difficult parameter to determine is the time limit for individuals in a zone.

### **Section 2.3 The Selection of an Accessibility Measure**

The theoretical guidelines presented in the first several sections of Chapter 2 were used as the first step in evaluating the different accessibility formulations for use in the proposed project. Based on the most basic definition of accessibility, a measure that incorporates characteristics of both the transportation system and land use, the spatial separation measure was deemed inadequate due to its lack of a land use component.

A second consideration in the evaluation of the various types of accessibility measures is the availability of data. Data availability in general was researched to serve another goal of this research — the incorporation of data regarding multiple modes. Factors beyond the traditional zone-to-zone travel time may influence users of the transportation system. For example, the presence of shelter at a bus stop on rainy or hot days may affect a person's travel behavior. Should biking and walking be included in multi-modal measurement, information such as bike lane presence and sidewalk continuity would be appropriate elements of an impedance factor.

In order to assess the level of detail that could be incorporated in the accessibility measure being developed, several medium and large Texas cities were surveyed. There was no data universally available beyond traditional attractions and impedance measures. For more information regarding the potential information to use in accessibility measures, see Bhat et al. (2000b). While several of the measures can use as detailed level of specifications as the researcher desires, the time-space measure, by its nature, demands a high level of detail. Due to its demand for detailed data that is largely unavailable, the time-space measure was found to be incompatible with the research goals of this project.

Next, several types of cumulative opportunities and gravity measures were evaluated regarding their performance using an actual data set from the North Central Texas Council of Governments (NCTCOG) encompassing the Dallas/Fort Worth area of Texas. Table 2.1 presents the six measures evaluated. Two are cumulative opportunities measures and four are gravity measures. The two cumulative opportunities measures tested had cut off times of 15 and 30 minutes. Average travel time to work in the study area is 24 minutes and to shopping is 16 minutes, therefore, 15 and 30 minutes appeared to be reasonable cut off times to explore.

Table 2.1 Accessibility Measures Evaluated

Type of Measure		Form of Measure	
Cumulative Opportunities		$A_i = \sum_j O_{jt}$	$O_{jt}$ = activity in zone $j$ where $j$ is within time $t$ of zone $i$ $t = 15$ minutes $t = 30$ minutes
Gravity Measures	Gaussian	$A_i = \sum_j O_j \exp\left[-(t_{ij}/t_*)^2 / (-2)\right]$	$t_{ij}$ = travel time between zones $i$ and $j$ $t_*$ = average travel time to each type of activity based on local travel diary data $t_*$ (work) = 24 min. $t_*$ (shopping) = 16 min. $t_*$ (recreation) = 15 min.
	Composite Impedance	$A_i = \ln \left[ \frac{1}{J} \sum_{j=1}^J \left( \frac{O_j^\alpha}{C_{ij}^\mu} \right) \right]$  where:  $C$ (equivalent auto in-vehicle time units) $= IVTT_{\text{auto}} + \beta * OVTT_{\text{auto}} +$ $\gamma * \text{Cost}_{\text{parking}}$	$J$ = total number of zones in the area  $\alpha_{\text{work}} = 0.7554$ $\alpha_{\text{shopping}} = 0.2868$ $\alpha_{\text{recreation}} = 0.1376$  $\mu_{\text{work}} = 2.6507$ $\mu_{\text{shopping}} = 3.078$ $\mu_{\text{recreation}} = 2.677$  $\beta_{\text{work}} = 0.3385$ $\gamma_{\text{shopping}} = 0.0992$  all other parameters are insignificant
	Distance as impedance (activity/distance)	$A_i = \ln \left[ \frac{1}{J} \sum_j \frac{O_j}{d_{ij}^\alpha} \right]$	$\alpha_{\text{work}} = 2.0347$ $\alpha_{\text{shopping}} = 2.5000$ $\alpha_{\text{recreation}} = 3.0751$
	In-vehicle-travel-time as impedance (activity/IVTT)	$A_i = \ln \left[ \frac{1}{J} \sum_j \frac{O_j}{IVTT_{ij}^\alpha} \right]$	$\alpha_{\text{work}} = 2.6194$ $\alpha_{\text{shopping}} = 3.1600$ $\alpha_{\text{recreation}} = 3.9191$

The four types of gravity measures chosen were designed to test various features of this type of measure. The first type evaluated was a Gaussian form of the measure. Local data were used to determine the point of inflection of the measure to accurately characterize how people in the area traveled. The other three measures are essentially a combined gravity/logsum measure.

Deriving locally-based parameters for the gravity accessibility measures using a multinomial logit form for destination choice leaves the researcher with an equation that is essentially the utility, or logsum, measure. Two of the measures were designed to specifically understand the effectiveness of using in-vehicle-travel-time as a measure of impedance versus network distance. The last type of gravity measure evaluated a more detailed form of impedance known as “composite impedance.” See Bhat et al. (2001) for a complete description of the measures evaluated and the estimation of local parameters.

The gravity measures in general performed better than the cumulative opportunities measures. Among the gravity measures the three gravity/logsum measures performed better than the Gaussian measure. Performance of the measures was based on several factors, including how well they showed local peaking in the study area, and how well they differentiated among different income groups and different population densities. In the end the gravity/logsum measure using composite impedance was chosen because of the versatility of its impedance component.

## Section 2.4 Equivalence of Gravity and Utility Measures

As developed and applied in this research the gravity and utility measures are functionally equivalent. In Table 2.1, the activity/distance and activity/IVTT measures are gravity-type accessibility measures with the addition of the natural log form as a scaling factor.

A utility accessibility measure begins with the utility of an activity in a zone  $j$  for a person in another zone  $i$ . Equation 2.5 represents a general utility function for accessibility to work.

$$V_{ij}^{work} = \alpha^{work} \ln(O_{j,work}) - \mu^{work} \ln(C_{ij}) \quad (\text{Eq. 2.5})$$

The probability that an individual in zone  $i$  will choose to participate in an activity in zone  $j$  is given by Equation 2.6.

$$P_{ij}^{work} = \left[ \frac{\exp(V_{ij}^{work})}{\sum_k \exp(V_{ik}^{work})} \right] \quad (\text{Eq. 2.6})$$

Substituting Equation 2.5 into Equation 2.4, gives Equation 2.7. The final formulation in Equation 2.7 presents the same notation as in Table 2.1. Therefore, the gravity measure of accessibility can be derived from a utility model.

$$A_i = \ln \left[ \frac{1}{J} \sum_j \exp(V_{ij}^{work}) \right] = \ln \left[ \frac{1}{J} \sum_{j=1}^J \left( \frac{O_{j,work}^\alpha}{C_{ij}^\mu} \right) \right] \quad (\text{Eq. 2.7})$$

A simple example of the accessibility of each zone in a two zone system for a particular purpose ( $P$ ), at a particular time of day ( $T$ ), via a specific mode ( $M$ ) is presented below. Equation 2.8 is the accessibility for zone 1 and Equation 2.9 is the accessibility for zone 2. Note that the  $M, T, P$  notation is implied in the equations below and not carried throughout the equation.

$$A(M, T, P)_1 = \ln \left[ \frac{1}{2} (\exp(\alpha \ln O_1 - \mu \ln C_{11}) + \exp(\alpha \ln O_2 - \mu \ln C_{12})) \right] \quad (\text{Eq. 2.8})$$

$$A(M, T, P)_2 = \ln \left[ \frac{1}{2} (\exp(\alpha \ln O_1 - \mu \ln C_{21}) + \exp(\alpha \ln O_2 - \mu \ln C_{22})) \right] \quad (\text{Eq. 2.9})$$



### 3. Aggregation

A primary consideration in evaluating the accessibility measures for the objectives of this study is the ability to aggregate the values that are calculated for each zone across a variety of dimensions. Wilson (1971) argues that the degree and type of disaggregation should be specified prior to the determination of accessibility measures. The dimensions of aggregation that were identified for this analysis are as follows:

- spatial;
- intermodal and network level of service attributes;
- time of day; and,
- trip purpose.

While work has been done regarding aggregation over any single dimension outlined above, the literature does not reveal research aimed at an aggregation procedure that addresses multiple dimensions. The sections below consider aggregation techniques for each dimension in turn, highlighting strengths and weaknesses of previous relevant work. The final section presents the aggregation procedure ultimately used in this study, along with some observations. Data from the Dallas/Fort Worth area are used to illustrate the aggregation techniques discussed below. The most disaggregate spatial unit of aggregation computed is the transportation analysis and process (TAP) zone.

#### Section 3.1 Aggregation Techniques for Specific Dimensions

##### *Spatial Aggregation*

Most of the literature on aggregation techniques concentrates on spatial aggregation. Spatial aggregation can be performed much like destination choice modeling, as summarized by Ben-Akiva and Lerman (1985), for the case where elemental destinations are aggregated into geographical zones. The random utility  $U_{in}$  of an aggregate alternative  $i$  to a decision maker  $n$  is given by the following expression:

$$U_{in} = \bar{V}_{in} + \frac{1}{\eta} \ln M_i + \frac{1}{\eta} \ln \left( \frac{1}{M_i} \sum_{l \in L_i} e^{\mu(V_{in} - \bar{V}_{in})} \right) + \epsilon_{in} \quad (\text{Eq. 3.1})$$

where

- $\eta$  = a parameter characterizing the presence of common unobserved zonal attributes affecting the attractiveness of zonal attributes (Daly 1979),
- $\varepsilon$  = random term distributed Identical Independently Distributed Gumbel,
- $L$  = the universal set of elemental alternatives,
- $l$  = an individual elemental alternative,
- $L_i$  = aggregates of elemental alternatives and non-overlapping subsets of  $L$ ,
- $M_i$  = the number of elemental alternatives in choice  $L_i$ , and
- $i = 1, \dots, I$  — an index denoting a particular aggregate alternative.

The first term of Equation 3.1 provides the average utility of elemental alternatives belonging to the aggregate alternative  $i$ , the second represents the size of  $i$ , the third measures the variability of the elemental utilities, and the fourth accommodates unobserved uncertainty. Using this formulation, the probability of a choice is proportional to its size.

This aggregation technique is particularly applicable for a utility-based accessibility measure, such as a logsum expression, which is explained below. The data are spatially aggregated (by zones) and the model is based on a random-utility representation of trip-maker preferences. Ferguson and Kanaroglou (1998) argued that the aggregated spatial logit model provides a mechanism to account for the shape of aggregate spatial units in spatial choice models. Daly (1979) provided an algorithm for estimating parameters of these models. A potential problem with spatial aggregation techniques can be attributed to irregularly shaped and sized zones. This is called the Modifiable Area Unit Problem (MAUP).

Another approach for spatial aggregation of utility-based measures is to use the expected maximum utility (logsum) of the lower-level nest of a nested logit model of mode and destination where the former is the higher-level nest. Equation 3.2 is an illustrative example of spatial aggregation over  $n$  destinations using a logsum expression:

$$\Gamma_{destinations} = \ln \left[ \sum_{i=1}^n \exp \left( \frac{V_{destination\ i}}{\eta} \right) \right] \quad (\text{Eq. 3.2})$$

where

- $\eta_{destinations}$  = a parameter characterizing the presence of common unobserved attributes affecting the attractiveness of zonal attributes,
- $V_{destination\ i}$  = the utility expression for destination  $i$ , and

$\Gamma_{destinations}$  = the expected value of the aggregate choice of  $n$  destinations.

### *Intermodal Aggregation*

Accessibility measures are mode-specific since they reflect the interaction between land development and transportation supply modes. Levinson and Kumar (1994) used a weighted average approach to aggregate accessibility measures over transportation modes. They multiplied each mode-specific accessibility index by the corresponding use probability (obtained from a mode choice analysis).

Davidson (1977) argued that accessibility should increase as another mode is added to an area. One difficulty faced when performing modal aggregation, using the simple weighted average technique, is the allocation of relatively high indices to areas with only a few fast modes and low indices to areas with higher average travel times, but additional modes. To avoid this pitfall when using gravity measures, modal aggregation could be performed using a weighted (by mode shares) average along with the parallel conductance formula suggested by Bhat et al. (1998). Bhat's formula places more emphasis on the number of modes via the use of dummy variables. This can be seen below in a brief example with three modes —  $M_1$ ,  $M_2$ , and  $M_3$ .

Equation 3.3 represents the average impedance function for all available transport modes, which is inversely related to land accessibility:

$$(1 - M_2) (1 - M_3) C_1 + M_2 (1 - M_3) \left( \frac{C_1}{1 + \frac{C_1}{C_2}} \right) + M_3 (1 - M_2) \left( \frac{C_1}{1 + \frac{C_1}{C_3}} \right) + M_2 M_3 \left( \frac{C_1}{1 + \frac{C_1}{C_2} + \frac{C_1}{C_3}} \right) \quad (\text{Eq. 3.3})$$

where

$C_i$  = the accessibility index for a certain region calculated using mode  $i$ , and  
 $M_i$  = a dummy variable for mode  $i$  (taking a value of 1 if the mode  $i$  is available, 0 otherwise).

The first term of Equation 3.3 applies for cases where  $M_1$  is the only available mode. The second term applies for cases where modes  $M_1$  and  $M_2$  are available, whereas the third term

applies for cases where  $M_1$  and  $M_3$  are the available modes. Finally, the last term applies for cases where the three considered modes are available.

Another approach for intermodal aggregation of utility-based measures is to use the expected maximum utility (logsum) of the upper-level nest of the previously described nested logit model.

$$\Gamma_{modes} = \ln \left\{ \sum_{j=1}^m \left[ \exp \left( \frac{V_{mode\ j}}{\eta_{mode}} \right) + \exp \left( \frac{\eta_{destinations} * \Gamma_{destinations}}{\eta_{modes}} \right) \right] \right\} \quad (\text{Eq. 3.4})$$

where

$\eta_{modes}$  = a parameter characterizing the presence of common unobserved attributes affecting the attractiveness of modal attributes,

$V_{mode\ j}$  = the utility expression for transport mode  $j$ , and

$\Gamma_{modes}$  = the expected value of the aggregate choice of  $m$  transport modes.

### *Aggregation Over Times of Day*

The characteristics of transportation systems, such as level of service attributes, often differ by time of day (e.g., AM peak, AM off-peak, PM peak, PM off-peak). Therefore, the definition of an accessibility index is often time-of-day specific.

No literature has been identified for aggregation of accessibility indices over times of day. One possible technique is to use a weighted average. As such, average peak-period measures (e.g., travel times) would receive a higher weight to reflect increased facility use. Similarly, a lower weight would be applied for off-peak times. One advantage of using this method is that variations in traffic flow are recognized based on peak-period fluctuations.

A utility-based logsum measure of a nested logit model provides a possible aggregation over times of day. A possible nested structure includes the number of trips an individual chooses as an upper-level nest and the selected times of day as a lower-level nest. The expected maximum utility of the different time-of-day alternatives is given by Equation 3.5:

$$\Gamma_{times\ of\ day} = \ln \left[ \sum_{i=1}^n \exp \left( \frac{V_{time\ slot\ i}}{\eta_{times\ of\ day}} \right) \right] \quad (\text{Eq. 3.5})$$

where

$\eta_{times\ of\ day}$  = a parameter characterizing the presence of common unobserved attributes affecting the attractiveness of time intervals attributes,

$V_{\text{times of day}}$  = the utility expression for time slot  $i$ , and

$\Gamma_{\text{times of day}}$  = the expected value of the maximum utility afforded by a choice across  $n$  time intervals.

### *Aggregation over Trip Purposes*

Accessibility indices are often meaningfully defined and interpreted for a specific trip purpose or activity – such as shopping (e.g., Handy 1993), wealth (e.g. Wachs and Kumagi 1973), and job trips. However, in some cases such indices might be aggregated to provide a more comprehensive measure of accessibility, that encompasses all (or several) trip purposes. Unfortunately, no literature has been identified for this type of aggregation.

One possible way to solve this problem is to weigh each purpose-specific index by the corresponding proportion of total trips for that purpose, as suggested for time of day and modes.

## **Section 3.2 Aggregation Methodology**

While some researchers have addressed the issue of aggregation across one dimension, as described above, no one has actively pursued aggregation across the multiple dimensions proposed here. As the discussion above demonstrates, there are many possible methods of aggregation. Aggregation over one dimension, i.e. summing accessibilities for one dimension for each possible combination of the other dimensions, is relatively straightforward, however, aggregation over multiple dimensions is a more descriptive tool for transportation planning. Admittedly aggregating over disparate dimensions is a difficult task, however, the framework described below offers an intuitive procedure grounded in traditional transportation methods.

### **Section 3.2.1 The Multinomial Logit Model as the Basis of Aggregation**

The aggregation methodology presented here is based on the multinomial logit (MNL) model (rather than the nested logit model) because this allows for flexible behavioral structures, and permits aggregation without any further model estimation, avoiding many pitfalls of previous related work. Thus, this aggregation technique requires the use of a joint MNL model where each alternative choice consists of a certain combination of a spatial unit, a time of day, a transport mode, and a trip type. Assuming independent random utility contributions over the

four dimensions (times of day, modes, spatial units, and purposes), the utility expression of the joint model becomes the sum of the utility expressions of four separate MNL models corresponding to each of the dimensions. Therefore, the constant terms of the joint model are nothing but the sum of the constant terms of the individual models, which can be simply estimated using the observed market shares.

To illustrate this, consider the case when there are two zones ( $Z_1$  and  $Z_2$ ), two modes ( $M_1$  and  $M_2$ ), two times of day ( $T_1$  and  $T_2$ ), and three trip purposes ( $P_1$ ,  $P_2$ , and  $P_3$ ). Assume that there are no common variables affecting the utility of the different dimensions. In our aggregation approach, we use only constants for each alternative along each dimension to make implementation easy; thus the assumption that there are no common variables affecting the utility of different dimensions is immediately satisfied. (Strictly speaking, one must consider the variations in travel impedance across modes and across times of day, which is considered in computing the disaggregate accessibility value for each zone, mode, time of day, and purpose; however, these variations are relatively small compared to the overall role of constants in determining choice along each of these dimensions.) Let the utility constant for residential location for zone  $Z_1$  be  $V_{Z_1}$  and for zone  $Z_2$  be  $V_{Z_2}$ . Similarly, let the utility constants for modes  $M_1$  and  $M_2$  be  $V_{M_1}$  and  $V_{M_2}$ , respectively; for times of day  $T_1$  and  $T_2$  be  $V_{T_1}$  and  $V_{T_2}$ , respectively; and for purposes  $P_1$ ,  $P_2$ , and  $P_3$  be  $V_{P_1}$ ,  $V_{P_2}$ , and  $V_{P_3}$ . Then we can write the probability of selecting zones  $Z_1$  and  $Z_2$  as:

$$\Pr(Z_1) = \frac{\exp(V_{Z_1})}{\exp(V_{Z_1}) + \exp(V_{Z_2})} \quad (\text{Eq. 3.6})$$

$$\Pr(Z_2) = \frac{\exp(V_{Z_2})}{\exp(V_{Z_1}) + \exp(V_{Z_2})} \quad (\text{Eq. 3.7})$$

Similarly, the probability of choice of modes, times of day, and purpose can be written as:

$$\Pr(M_1) = \frac{\exp(V_{M_1})}{\exp(V_{M_1}) + \exp(V_{M_2})} \quad (\text{Eq. 3.8})$$

$$\Pr(M_2) = \frac{\exp(V_{M_2})}{\exp(V_{M_1}) + \exp(V_{M_2})} \quad (\text{Eq. 3.9})$$

$$\Pr(T_1) = \frac{\exp(V_{T_1})}{\exp(V_{T_1}) + \exp(V_{T_2})} \quad (\text{Eq. 3.10})$$

$$\Pr(T_2) = \frac{\exp(V_{T_2})}{\exp(V_{T_1}) + \exp(V_{T_2})} \quad (\text{Eq. 3.11})$$

$$\Pr(P_1) = \frac{\exp(V_{P_1})}{\exp(V_{P_1}) + \exp(V_{P_2}) + \exp(V_{P_3})} \quad (\text{Eq. 3.12})$$

$$\Pr(P_2) = \frac{\exp(V_{P_2})}{\exp(V_{P_1}) + \exp(V_{P_2}) + \exp(V_{P_3})} \quad (\text{Eq. 3.13})$$

$$\Pr(P_3) = \frac{\exp(V_{P_3})}{\exp(V_{P_1}) + \exp(V_{P_2}) + \exp(V_{P_3})} \quad (\text{Eq. 3.14})$$

The combined probability of selecting a zone  $Z_I$  for residence, and selecting mode  $M_I$  during time of day  $T_I$  to pursue a trip purpose  $P_I$  may be written as:

$$\begin{aligned} \Pr(Z_1, M_1, T_1, P_1) &= \Pr(Z_1) \times \Pr(M_1) \times \Pr(T_1) \times \Pr(P_1) \\ &= \frac{\exp(V_{Z_1})}{\exp(V_{Z_1}) + \exp(V_{Z_2})} \times \frac{\exp(V_{M_1})}{\exp(V_{M_1}) + \exp(V_{M_2})} \times \frac{\exp(V_{T_1})}{\exp(V_{T_1}) + \exp(V_{T_2})} \times \frac{\exp(V_{P_1})}{\exp(V_{P_1}) + \exp(V_{P_2}) + \exp(V_{P_3})} \\ &= \frac{\exp(V_{Z_1} + V_{M_1} + V_{T_1} + V_{P_1})}{\exp(V_{Z_1} + V_{M_1} + V_{T_1} + V_{P_1}) + \exp(V_{Z_1} + V_{M_1} + V_{T_1} + V_{P_2}) + \dots + \exp(V_{Z_2} + V_{M_2} + V_{T_2} + V_{P_3})} \end{aligned} \quad (\text{Eq. 3.15})$$

The denominator will have 24 terms, each term representing the utility of a combined multidimensional choice of zone, time of day, mode, and purpose. This result is the same as estimating a joint multidimensional MNL model with each alternative representing a combination of zone, trip mode, time of day, and purpose. Thus, the utility of a joint alternative is simply the sum of the constants estimated from unidimensional MNL models:

$$V(Z_1, M_1, T_1, P_1) = V_{Z_1} + V_{M_1} + V_{T_1} + V_{P_1} \quad (\text{Eq. 3.16})$$

The above equation does not consider the utility of each combination of dimensions due to the disaggregate accessibility associated with each joint choice. The disaggregate accessibility value was suppressed above since it violates the assumption used in the derivations that there are no common variables affecting the utility of the different dimensions. In fact, the impedance variables (times and costs) used in computing the disaggregate accessibility are determined by combinations of mode and time of day. Thus, to be technically correct, one must estimate a joint

MNL model with each combination being an alternative, rather than infer the results of this joint MNL model using easier to estimate unidimensional MNL constants. However, as indicated earlier, the variations in the times and costs across modes and times of day, and their impacts on the utility of each joint choice are small compared to the role of constants. So, we simply add the disaggregate accessibility to equation 3.16 and write:

$$V(Z_1, M_1, T_1, P_1) = A(Z_1, M_1, T_1, P_1) + V_{Z_1} + V_{M_1} + V_{T_1} + V_{P_1} \quad (\text{Eq. 3.17})$$

where:

$$A(Z_1, M_1, T_1, P_1) = \ln \left[ \frac{1}{J} \sum_j \exp(\alpha \ln O_{P_1, j} - \mu \ln C_{i, j, T_1}) \right] = \ln \left[ \frac{1}{J} \sum_j \frac{O_{P_1, j}^\alpha}{C_{i, j, T_1}^\mu} \right] \quad (\text{Eq. 3.18})$$

The above disaggregate accessibility takes the form discussed in Chapter 2;  $O_{P_1, j}$  refers to the base measure corresponding to purpose  $P_1$  and for each destination zone  $j$  and  $C_{i, j, T_1}$  is the impedance between zone  $i$  and zone  $j$  at time  $T_1$ .  $\alpha$  and  $\mu$  are obtained from the destination choice model, as discussed in Chapter 2.

### Section 3.2.2 Obtaining Constants

The constant terms for each dimension can be obtained in a straightforward manner. To determine the zonal constant, we can use the residence population shares. Then, in the MNL model, the following should hold:

$$S(Z_1) = \frac{\exp(V_{Z_1})}{\exp(V_{Z_1}) + \exp(V_{Z_2})} \quad \text{and} \quad S(Z_2) = \frac{\exp(V_{Z_2})}{\exp(V_{Z_1}) + \exp(V_{Z_2})} \quad (\text{Eq. 3.19})$$

Let  $Z_2$  be the population with the lower residence population. Then, we can write:

$$V_{Z_1} = \ln \left[ \frac{S(Z_1)}{S(Z_2)} \right] \quad \text{and} \quad V_{Z_2} = 0 \quad (\text{Eq. 3.20})$$

Knowing the residence population in each zone then provides the constant values for each zone. Similarly, we can compute the constant for each mode, time of day, and purpose using the market share of trips undertaken by that mode, time of day, and purpose.

$$V_{M_1} = \ln \left[ \frac{S(M_1)}{S(M_2)} \right] \quad \text{and} \quad V_{M_2} = 0 \quad (M_2 \text{ has the lower share}) \quad (\text{Eq. 3.21})$$

$$V_{T_1} = \ln \left[ \frac{S(T_1)}{S(T_2)} \right] \quad \text{and} \quad V_{T_2} = 0 \quad (T_2 \text{ has the lower share}) \quad (\text{Eq. 3.22})$$

$$V_{P_1} = \ln \left[ \frac{S(P_1)}{S(P_3)} \right], \quad V_{P_2} = \ln \left[ \frac{S(P_2)}{S(P_3)} \right] \quad \text{and} \quad V_{P_3} = 0 \quad (P_3 \text{ has the lowest share}) \quad (\text{Eq. 3.23})$$

The presentation above assumes that the constants for each alternative for a particular dimension is the same for different alternatives of other dimensions (for example, the modal constants are assumed to be equal for different purposes). This assumption is for presentation ease. In our implementation, we obtain different constants along each dimension for different alternatives along other dimensions. The market shares for mode, time of day, and purpose used in computing the constants for the Dallas/Fort Worth area are provided in Appendix A.

### Section 3.3 Aggregation Process

Let the accessibility measure at the most disaggregate level be  $A(Z_i, M_k, T_l, P_q)$  for zone  $i$ , mode  $k$ , time of day  $l$ , and purpose  $q$ . Then, the (notationally) generalized version of Equation 3.17 is:

$$V(Z_i, M_k, T_l, P_q) = A(Z_i, M_k, T_l, P_q) + V_{Z_i} + V_{M_k} + V_{T_l} + V_{P_q} \quad (\text{Eq. 3.24})$$

The above equation can be used to compute the aggregate accessibility along any combination of alternatives, where each alternative is represented by a zone, mode, time of day, and purpose. Thus, the aggregate accessibility of a set  $S$  corresponding to a certain combination of alternatives is computed as:

$$\text{Aggregate Accessibility } (S) = \ln \left[ \frac{1}{D} \sum_{i,k,l,q} \delta_{i,k,l,q}^S \exp\{V(Z_i, M_k, T_l, P_q)\} \right] \quad (\text{Eq. 3.25})$$

where

$\delta_{i,k,l,q}^S = 1$  if the combination  $\{i,k,l,q\}$  is included in set  $S$  and 0 otherwise, and

$$D = \sum_{i,k,l,q} \delta_{i,k,l,q}^S \left[ \exp(V_{Z_i}) + \exp(V_{M_k}) + \exp(V_{T_l}) + \exp(V_{P_q}) \right] \quad (\text{Eq. 3.26})$$

This aggregation formula (Eq. 3.25 and 3.26) has the same functional form as the disaggregate formulation (Eq. 3.17 and 3.18).  $D$  serves as a normalizing function to ensure that the aggregate accessibility values are in the same range as the disaggregate accessibility values.

The aggregate accessibility in Equation 3.25 can be computed by including the constant terms  $V_{Z_i}$ ,  $V_{M_k}$ ,  $V_{T_l}$ , and  $V_{P_q}$  or by suppressing the constant terms. The first case corresponds to weighting the disaggregate accessibility values based on the number of individuals and individual trips encountering each disaggregate accessibility value. This would be the relevant accessibility measure if the objective is to compute accessibility given the prevailing residential location and trip-making patterns. However, if the objective were to compute a measure of aggregate accessibility, regardless of current residential and trip-making patterns, the appropriate aggregation measure would suppress the constant terms. In this latter case,  $D$  becomes equivalent to the number of alternatives involved in the aggregation.

### Section 3.4 A Simple Aggregation Example

Let  $A(Z_1, M_k, T_l, P_q)$  and  $A(Z_2, M_k, T_l, P_q)$  be the disaggregate accessibilities for zones 1 and 2, respectively, corresponding to mode  $k$ , time of day  $l$ , and purpose  $q$ . Assume that  $A(Z_1, M_k, T_l, P_q) = 2$  and  $A(Z_2, M_k, T_l, P_q) = 3$ . Also, let the fraction of population shares between zones 1 and 2 be 0.8 and 0.2. In this case,  $V_{Z_1} = \ln(0.8/0.2) = \ln 4$  and  $V_{Z_2} = 0$ . Therefore, the aggregate accessibility value across zones 1 and 2 for mode  $k$ , time of day  $l$ , and purpose  $q$  is:

$$\begin{aligned} \text{Aggregate Accessibility}_{\text{weighted}} &= \ln \left[ \frac{1}{\exp(\ln 4) + \exp(0)} \cdot \{\exp(2 + \ln 4) + \exp(3 + 0)\} \right] \\ &= \ln \left[ \frac{1}{5} \cdot \{\exp(2) \cdot 4 + \exp(3)\} \right] \\ &= 2.295 \end{aligned} \tag{Eq. 3.27}$$

The above accessibility corresponds to the case of weighting based on population shares. The unweighted aggregate accessibility would be:

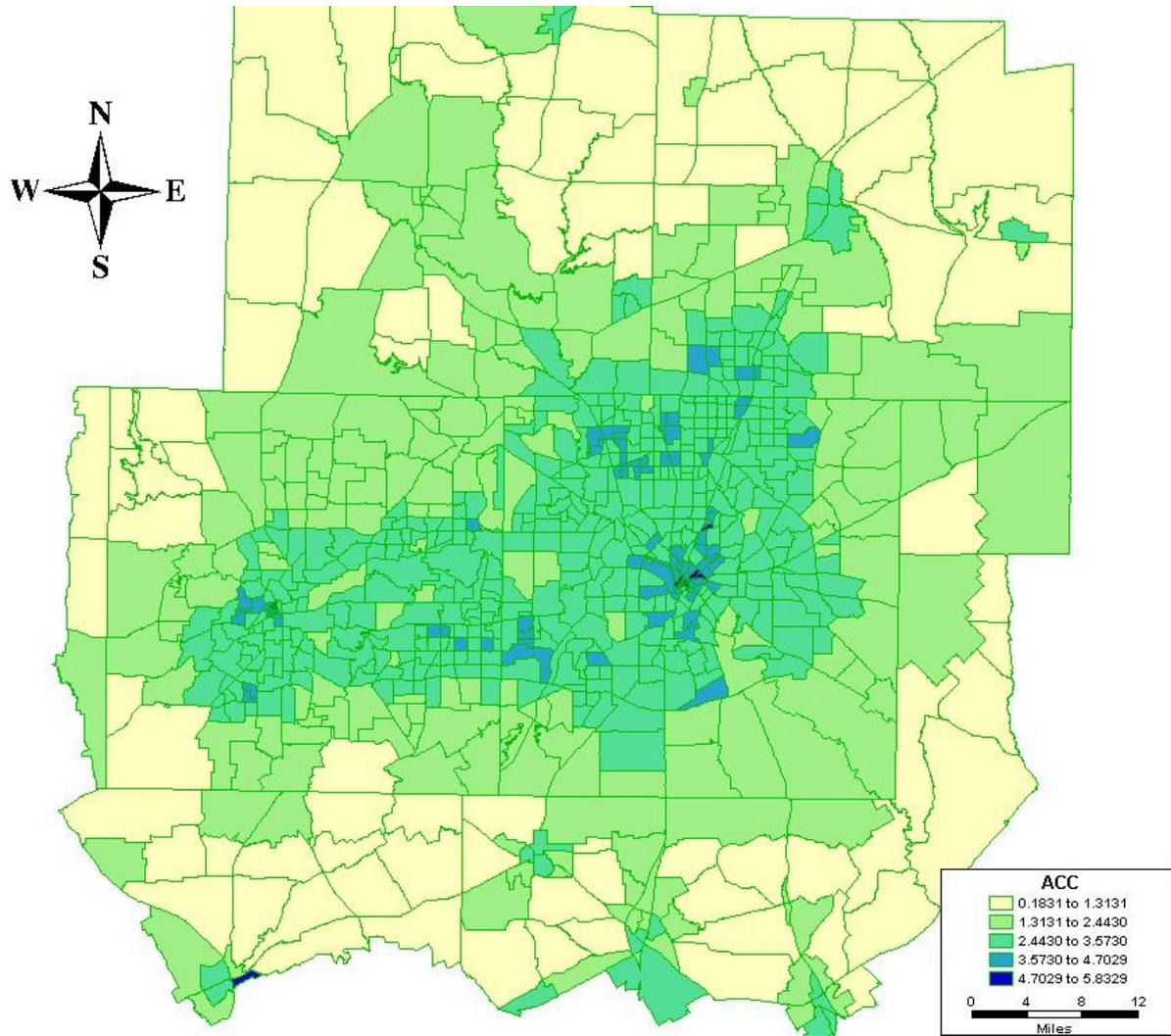
$$\begin{aligned} \text{Aggregate Accessibility}_{\text{unweighted}} &= \ln \left[ \frac{1}{2} \cdot \{\exp(2) + \exp(3)\} \right] \\ &= 2.62 \end{aligned} \tag{Eq 3.28}$$

Note also that if the disaggregate accessibility of both zones are equal, then the aggregate accessibility equals the individual disaggregate accessibilities. (This holds for both the weighted and unweighted aggregation cases.)

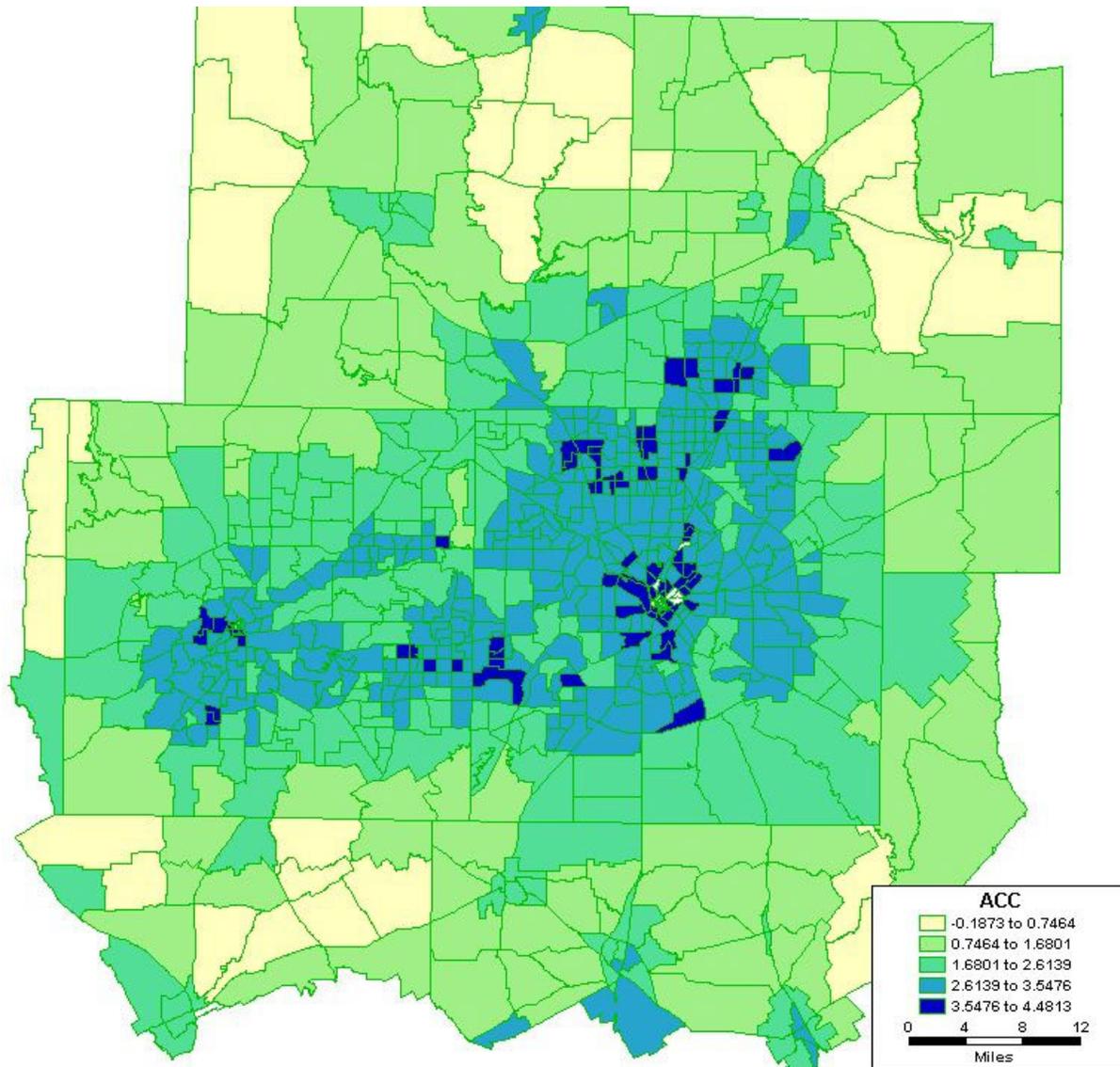
### **Section 3.5 An Illustrative Example of Aggregation**

This aggregation procedure was applied to the Dallas/Fort Worth data set. Fifteen different maps, representing fifteen different aggregation scenarios over any possible combination of dimensions, were generated. This section presents an illustrative example of the aggregation procedure used. Three maps of accessibility estimated at the most disaggregate level are shown, along with a map where aggregation was performed over one dimension.

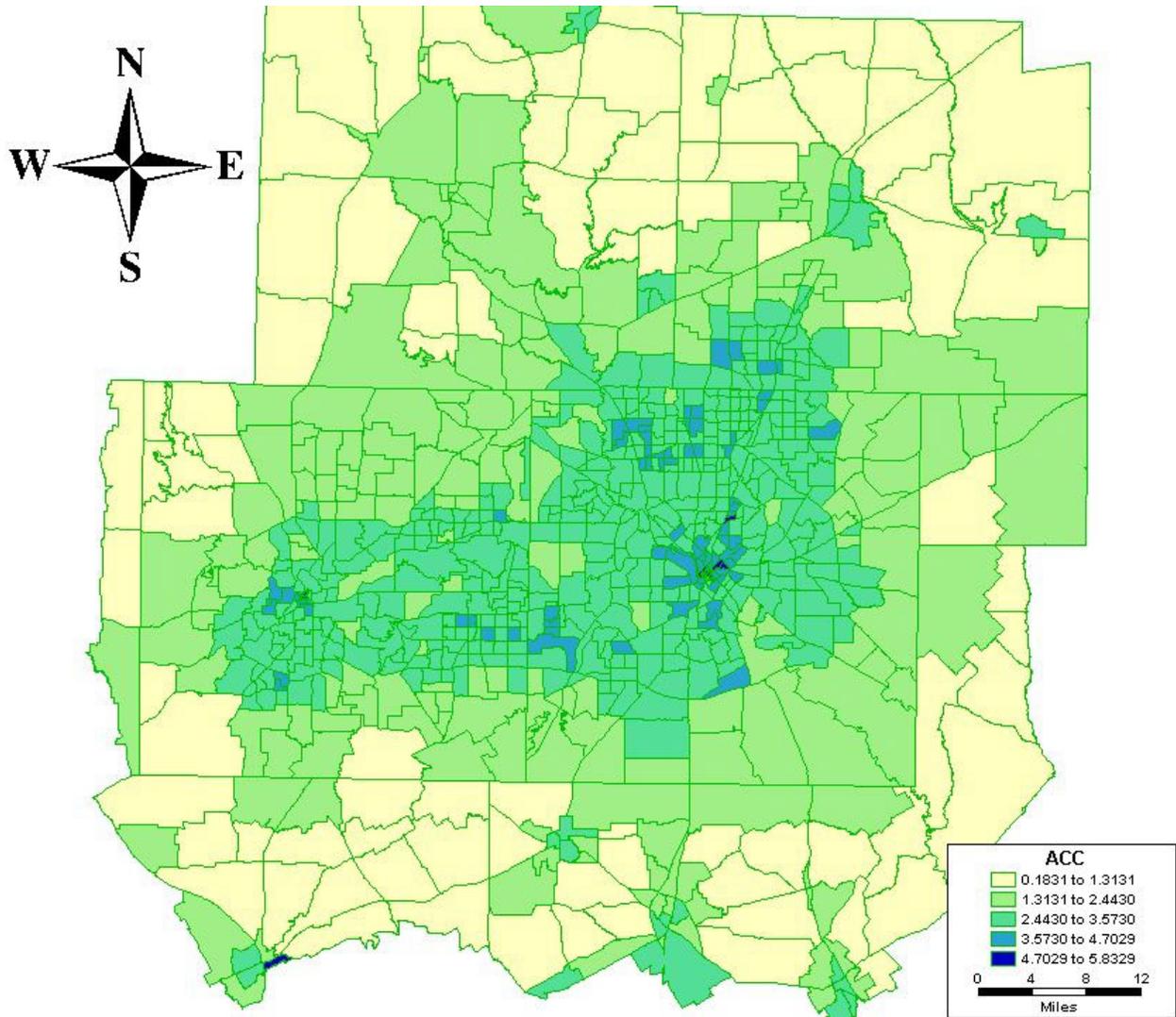
Figures 3.1, 3.2, and 3.3 below show results of accessibility for the Dallas/Fort Worth Metropolitan Area for the trip purposes of shopping, social-recreational, and work, respectively, all using the highway mode at the peak travel time. Zones in Dallas's central business district (CBD) have the highest accessibility values. As expected, as the distance of a TAP zone from either the Dallas or Fort Worth CBD increases, its accessibility value decreases. This same observation can be made for the accessibility values across all trip purposes using the same transport mode and time of day, as illustrated in Figure 3.4 below. Therefore, order was preserved in this example.



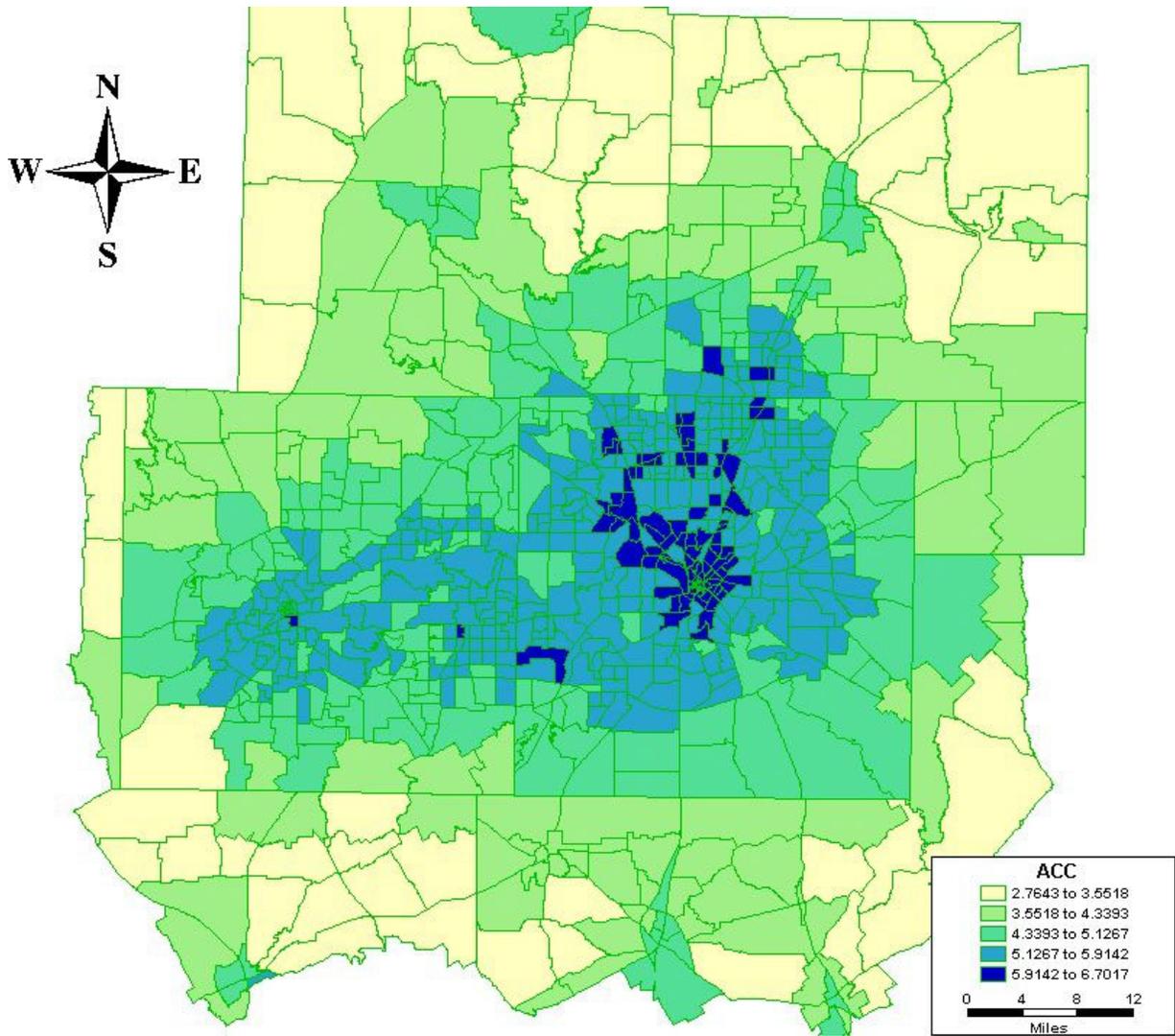
*Figure 3.1 Map of the Dallas-Fort Worth Metropolitan Area with Accessibility Values for Shopping Trips Using the Highway Mode at the Peak Travel Time*



*Figure 3.2 Map of the Dallas-Fort Worth Metropolitan Area with Accessibility Values for Social-Recreational Trips Using the Highway Mode at the Peak Travel Time*



*Figure 3.3 Map of the Dallas-Fort Worth Metropolitan Area with Accessibility Values for Work Trips Using the Highway Mode at the Peak Travel Time*



*Figure 3.4 Map of the Dallas-Fort Worth Metropolitan Area with Accessibility Values for All Trips Purposes Using the Highway Mode at the Peak Travel Time*



## **4. Software Program Design Details for Computing Accessibility**

Once the aggregation procedure was determined and found to meet the qualifications described above, the process was codified in a graphic interface software for use with TransCAD. This add-in is called Urban Accessibility Index. It has been built entirely with GISDK, a programming language intended for customizing TransCAD operations. GISDK, provided as an add-in to newer versions of TransCAD, enables the TransCAD programmer to provide user-friendly Graphical User Interfaces that allow lay users to perform complex operations. The manipulation of geographic databases and maps, an integral part of computing accessibility, are ideal uses of TransCAD. Since GISDK is directly linked to all TransCAD operations and is intended to provide a user interface, it was the ideal programming language to build the Urban Accessibility Index add-in.

The software is a Windows-based interface that enables the user to obtain a GIS type output of a measure of accessibility that takes into account the mode of transport used, time of day, the purpose of the trip made, and the traffic zones of the city being analyzed. The software can be used as a powerful tool to evaluate the impact of new planning scenarios on the accessibilities of a region, to identify regions in a city with relatively low or relatively high accessibility, and numerous other uses where accessibility may be an important factor to consider. The user's guide is provided as Appendix B. It briefly explains the concepts implemented, educates the user on the implications of the choices she or he makes in its use, and also provides detailed step-by-step instructions on its use.

The software has the versatility to compute accessibility for any city or region while at the same time providing a high ease of use for the cities of Dallas/Fort Worth (D/FW) and Austin, Texas. The current data for these cities comes with the software package and the user only has to provide his or her preferences for each run without needing any knowledge of the structure of the data set. These data files include zone-to-zone impedance values (including transit, where available) and attractions data. In this case that is park acreage for the social-recreation trip purpose and employment data for the shopping and work trip purposes. If the user wishes to run the software for custom regions or different data sets for D/FW and Austin, he or

she needs to prepare input data in defined formats and must have a good working knowledge of the data set.

The software is designed to prompt the user for the data to be used (provided by the user or built-in data sets), dimensions over which to aggregate, and area-specific parameters. The minimum data required to run the program are a database file of the zone-to-zone impedances and a second database file with data describing the attractions of interest to the user. The software performs basic cross-checking of the files for completeness and compatibility with TransCAD. The user’s guide provides detailed formatting instructions (see Appendix B). A user is not limited to the type of attractions data built into the software. Annual sales figures or floor area might be suitable attractions variables.

Parameters developed from relevant travel diary data are included in the software to represent small, medium, and large Texas cities. Knowledgeable users may choose to provide parameters developed for their particular area of interest. There is always the option to use a combination of built-in and user-provided data. For example, the user may choose to add new trip purpose data and continue to use the built-in impedance data for one of the data sets that comes with the software.

Sixteen levels of aggregation are available in the software. They represent all the combinations available with the four dimensions of spatial unit, trip purpose, time of day, and mode. Table 4.1 lists all the available aggregation combinations available with this software.

*Table 4.1 Possible Aggregation Combinations  
Using the Urban Accessibility Index Add-In*

No Aggregation	A run for a specified time of day, trip purpose, mode used for the smallest spatial unit
Mode Only	A run for a specified time of day, trip purpose aggregated across both modes for the smallest spatial unit
Trip Purpose Only	A run for a specified time of day and mode aggregated across purposes for the smallest spatial unit

Table 4.1 continued

Time of Day Only	A run for a specified trip purpose and mode aggregated across all times of day for the smallest spatial unit
Zone Only	A run for a specified trip purpose, time of day and mode aggregated across spatial units
Mode and Time of Day	A run for a specified trip purpose aggregated across modes and times of day for the smallest spatial unit
Mode and Trip Purpose	A run for a specified time of day aggregated across modes and trip purposes for the smallest spatial unit
Mode and Zone	A run for a specified time of day and trip purpose aggregated across modes and spatial units
Trip Purpose and Time of Day	A run for a specified mode aggregated across times of day and trip purposes for the smallest spatial unit
Trip Purpose and Zone	A run for a specified time of day and mode aggregated across trip purposes and spatial units
Time of Day and Zone	A run for a specified trip purpose and mode aggregated across times of day and spatial units
Mode, Trip Purpose and Time of Day	A run aggregating across modes, trip purposes and times of day for the smallest spatial unit
Mode, Trip Purpose and Zone	A run for a specified time of day aggregated across modes, trip purposes and spatial units
Trip Purpose, Time of Day and Zone	A run for a specified mode aggregated across trip purposes, times of day and spatial units
Mode, Time of Day and Zone	A run for a specified trip purpose aggregated across modes, times of day, and spatial units
All Levels	A run aggregating across all four dimensions

Output from the software program consists of a map with different colors indicating zones with relatively high and relatively low accessibility. The user can choose the number of classes with which to present the data. They can also choose whether or not the classes have an equal number of zones in each classification or if each classification represents an equal range of values of accessibility. Besides the map, the results are presented in a table. This allows the user to save the data for future use and to include the results with other TransCAD layers. The output can be analyzed and manipulated in the same manner as any other layer in a Graphic Information System.

A map comparison tool is provided as an add-in to the software. This tool can be used to compare values from different accessibility runs of the program to get a clear picture of the impact of each variable on accessibility at a zonal level. The map comparison tool plots the difference of values between two runs for the same region on the map of that region. This format allows for an easy-to-interpret graphical presentation of changes in accessibility due to changes in the land use, transportation system, or both. As with a regular run of the software, it also provides the user with a table of the results.

## 5. Conclusion and Recommendations

In order to assess transportation systems, transportation professionals seek ways to incorporate information beyond the traditional mobility measures. A measure seeing increasing use is an accessibility index that includes information about activities or destinations (presumably the instigators of travel). While this concept has been around for decades, it is not yet a formal part of transportation planning; thus, there are many interpretations and permutations of this measure.

A look at the literature reveals a wealth of information regarding the theory and specific construction of accessibility measures. Using this information, a sound theoretical basis was formulated and provided a first step in the evaluation of existing measures (Bhat et al. 2000a).

After assessing the availability of impedance and attractions data in Texas (Bhat et al. 2001), real data from the Dallas/Fort Worth region in Texas was used for the final analysis of a set of measures representing several types of accessibility. The performance of the formulations using several different criteria provided evidence of how the various formulations would perform in real-life situations. This process is detailed in Bhat et al. (2001).

The real contribution of this research is in the methodology developed for the aggregation of the spatial data. The technique developed here draws from the multinomial logit model, which is a workhorse of transportation planning. Although a number assigned by the accessibility measure is dimensionless, it offers a relative comparison of areas. In order to preserve the sense of this relative quality of the results, the results of aggregation are scaled to the highest value obtained under the most disaggregate evaluation. This allows for a meaningful comparison among different aggregation scenarios.

The chosen accessibility measure and the techniques developed above were then incorporated into a software package that offers flexibility to the user in many different areas. Users may input their own data or, if they are in one of the two default areas, may use the information included regarding these areas. They may input parameters for activities and impedance that are locally derived, or use the default measures for large, medium, and small cities. Results may be presented as color-coded maps, or as database outputs; when comparing two different runs, results can be displayed with a map showing the *differences* in accessibility.

Thanks to methodical construction from basic accessibility principles and demonstrations using real-life data, this work provides a careful consideration of past efforts and offers a valuable tool for present and future implementation of accessibility measures. Although the aggregation method presented here advances the field, there are many areas requiring attention. First, the different results from using weighted and unweighted aggregation methodologies needs to be evaluated more thoroughly. Second, a comparison of the different levels of aggregation for different size study areas needs to be explored. And third, the default data included in the software needs to be expanded to more areas.

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## **Appendix A**

### **Market Shares for Dallas/Fort Worth**



*Table A.1 Market Shares for Time-of-day Distribution of Considered Trips in the Dallas/Fort Worth Area*

	Number of Observations	Percentage
Home-Based work trips	5615	25.79%
Home-Based shopping	1959	9.00
Home-Based socio-recreational	2450	11.25
Home-Based personal business	1733	7.96
Home-Based community	532	2.44
Home-Based pick-up/drop-off	2454	11.27
Non home-based trips	7032	32.29
Total	21,775	100%

*Table A.2 Time Distribution Based on Observations (%)*

	Morning AM	Off-Peak	AM Peak	PM Off-Peak	PM Peak	Evening	Total
Recreational	3%	5	9	14	23	46	100%
Shopping	0.5	3	15.5	26.5	27	27.5	100
Personal	1	11	23	28	21	16	100
Community	1	6	10	7	17	59	100



## **Appendix B**

### **User's Guide for Accessibility Software**



# **Urban Accessibility Index**

## **User's Guide**

**Developed by The University of Texas at Austin  
for  
Texas Department of Transportation**

**October 2002**



# 1. Introduction

Welcome to the Urban Accessibility Index add-in to TransCAD. This software package has been developed by the Transportation Engineering division of the University of Texas at Austin for the Texas Department of Transportation (TxDOT). The software, which is a custom add-in to TransCAD, is a Windows-based interface that enables the user to obtain a GIS-type output of a measure of accessibility that takes into account the mode of transport used, time of day, the purpose of the trip made, and the spatial unit of the data (generally traffic zones) of the city being analyzed. The software can be used as a powerful tool to evaluate the impact of new planning scenarios on the accessibilities of a region and to identify regions in a city with relatively high and relatively low accessibility. This user's guide briefly explains the concepts behind the methodology, educates the user on the potential consequences of the choices they make in its use, and also provides detailed step-by-step instructions on its use.

The next section of this chapter describes the basic concepts behind the accessibility measure computed by the software. Following that is a brief description of the outputs available. Chapter 2 provides a description of the specifications for data sets built into the software and the requirements for user-provided data. It concludes with a description of the installation procedure for the software. Chapter 3 provides step-by-step instructions for using the built-in data sets. Chapter 4 provides step-by-step instructions for computing the most disaggregate level of accessibility for user-provided data. Chapters 5 through 19 provide step-by-step instructions for computing the various combinations of aggregation using user-proved data. Chapter 20 provides a description of output files and how to manipulate them. Lastly, Chapter 21 describes how to produce a map that compares the results of two runs.

## **Accessibility Measure Used**

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Prior research concluded that a gravity accessibility measure based on utility theory is the one best suited for this project. See Chapter 2 of *Development of an Urban Accessibility Index: Formulations, Aggregation, and Application* for a more thorough description. Accessibility is dimensionless and can be used only in relative comparisons.

The basic equation used to compute accessibility at the most disaggregate level is:

$$Acc_i = \ln \left[ \sum_{j=1}^J \left( \frac{1}{J} \right) \left( \frac{O_j^\alpha}{C_{ij}^\mu} \right) \right] \quad (\text{Eq. B.1})$$

In this equation,

$\alpha, \mu$  = parameters estimated from destination mode choice models for the region under consideration (default values are provided in the software or they can be added by the knowledgeable user. See Step 3-4),

$O_j$  = sum of all measures of attractiveness for traffic zone  $j$  (dependent on trip purpose), and

$C_{ij} = \gamma IVTT + \theta OVTT + \lambda \text{Cost}$ . This is the impedance measure between zones  $i$  and  $j$  expressed in IVTT (in-vehicle travel time) units. This is dependent on the mode of travel used and the time of day of the trip. Default values are provided or, the knowledgeable user can provide region-specific values. See Step 3-4.

### **Aggregating Accessibility Measures**

A unique aspect of this software is the ability to aggregate disaggregate (zone-specific, mode-specific, trip-purpose-specific, and time-of-day-specific values) in a variety of combinations that may be useful to the user for analysis purposes. This means that the user can obtain aggregate accessibilities across any combination of the following:

- all traffic zones;
- trip purposes (3) – work, shopping and social-recreation;
- times of day (6) – morning, AM peak, AM off-peak, PM off-peak, PM peak, evening;  
and
- modes (2) – any two user named modes.

The aggregation process for each dimension is dependent upon a weighting factor unique to each dimension. For trip purposes, times of day, and modes, the user will be asked to input market shares only if they are aggregating over those purposes. See Chapters 6, 7, and 5 respectively to see these input screens. Spatial aggregation is weighted by population. This value is unique to

each of the spatial units and is best entered as a column in the attractions data file. This particular aggregation factor is referred to as the zonal constants throughout this document. See Chapter 2 for more information about including this data. Using these weights provides an accessibility value that is dependent upon prevailing residential location and trip-making patterns in a given area. In some cases it might be desirable not to weight the results. An aggregate accessibility measure computed in this manner would provide an accessibility value that disregards these prevailing behaviors. See Development of an Urban Accessibility Index: Formulations, Aggregation, and Application for a detailed description. In this case all ones should be entered into the screens prompting input for the market shares for trip purpose, time of day, and mode.

Each time the user goes through the screens of the software to compute accessibility for a scenario will be referred to as a *run*. The mathematical formulation of the accessibility computation allows for comparison of any two runs for a particular region. However, the program cannot compare accessibility maps from different regions. Comparison of accessibility values for a particular region is meaningful across different levels of aggregation. Sixteen levels of aggregation are possible:

1. No Aggregation – a run for a specified time of day, trip purpose, mode used for each traffic zone. This is also referred to as the disaggregate level. For the example above with three trip purposes, six times of day and two modes there would be 36 different disaggregate runs representing all the different combinations;
2. Mode Only – a run for a specified time of day and trip purpose aggregated across both modes for each traffic zone;
3. Trip Purpose Only – a run for a specified time of day and mode aggregated across purposes for each traffic zone;
4. Time of Day Only – a run for a specified trip purpose and mode aggregated across all times of day for each traffic zone;
5. Zone Only – a run for a specified trip purpose, time of day, and mode aggregated across traffic zones;
6. Mode and Time of Day – a run for a specified trip purpose aggregated across modes and times of day for each traffic zone;

7. Mode and Trip Purpose – a run for a specified time of day aggregated across modes and trip purposes for each traffic zone;
8. Mode and Zone – a run for a specified time of day and trip purpose aggregated across modes and traffic zones;
9. Trip Purpose and Time of Day – a run for a specified mode aggregated across times of day and trip purposes for each traffic zone;
10. Trip Purpose and Zone – a run for a specified time of day and mode aggregated across trip purposes and traffic zones;
11. Time of Day and Zone – a run for a specified trip purpose and mode aggregated across times of day and traffic zones;
12. Mode, Trip Purpose and Time of Day – a run aggregating across modes, trip purposes, and times of day for each traffic zone;
13. Mode, Trip Purpose and Zone – a run for a specified time of day aggregated across modes, trip purposes, and zones;
14. Trip Purpose, Time of Day and Zone – a run for a specified mode aggregated across trip purposes, times of day, and traffic zones;
15. Mode, Time of Day and Zone – a run for a specified trip purpose aggregated across modes, times of day, and traffic zones; and
16. All Levels – a run aggregating across all four parameters.

The user can run a data set through any of the 16 levels of aggregation (described in Chapter 3 for the built-in data and in Chapters 5-19 for user-provided data) and compare the output data using the map comparison add-on to the software (described in Chapter 21).

## 2. Getting Started

### Data Specifications

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The software has the versatility to compute accessibility for any city or region while at the same time providing a high ease of use for the cities of Dallas/Fort Worth (DFW) and Austin, Texas. All the current data for these cities comes with the software package and the user only has to provide his or her preferences for each run without needing any knowledge of the structure of the data set. If the user wishes to run the software for custom regions or different data sets for DFW and Austin, he or she needs to prepare input data in defined formats and must have a good knowledge of the data set.

### Built-In Data Sets

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#### Dallas/ Fort Worth

The built-in DFW data set is at the transportation analysis and process (TAP) zone level as defined by TxDOT for the DFW region. The file inventory for DFW along with a brief description of each file follows.

1. **TAP919.map** and associated files – TransCAD GIS file for the DFW region by TAP zone.
2. **tapdemo.dbf** – data on employment, park space and other attraction variables by TAP zone
3. **zonedata.dbf** – data on impedance variables between each pair of TAP zones for both the highway mode and transit mode.
4. **tap-counties.dbf** – a data file that groups TAP zones into counties (necessary for aggregating accessibility measures over counties).
5. **tap-tad.dbf** – A data file that groups TAP zones into TAD zones, a traffic zonal designation that is slightly smaller in size than counties but larger than TAP zones.

After installation please verify that these files are present in the directory: **c:\accessibility\data**.

#### Austin

The Austin data set is at the traffic serial zone (TSZ) level as defined by TxDOT for the Austin region. The file inventory for Austin along with a brief description of each file follows.

1. **austin\_tsz.map** and associated files – TransCAD GIS file for the Austin by TSZ.

2. **austin\_att.dbf** - data on employment, parks pace and other attraction variables by TSZ.
3. **austin\_imp.dbf** - data on impedance variables between each pair of TSZs.

After installation please verify that these files are present in the directory **c:\accessibility\data**.

### **User-Provided Data Sets**

---

The software can also compute accessibility measures and display them on a TransCAD map for data and regions defined by the user. The input data format must follow the requirements detailed in this manual. The program will not work, or may produce erroneous results if these guidelines are not followed.

To run the program for a custom data set and/or region the user must first upload the files described in Table B.1. The table provides format requirements and pertinent comments.

Table B.1 Format Requirements for User-Provided Data

<b>Data</b>	<b>Format</b>	<b>Comments</b>
Zone Map	A TransCAD GIS map file containing the traffic zones being used for the analysis (*.map extension and its associated files).	A TransCAD map usually has numerous files associated with it, which may end up getting lost when transferring between directories. Before running the program, test that the file is okay by opening it in TransCAD to see if it loads properly. If the map is available as an ESRI® shape file, open it in TransCAD and save it as a .map file in a directory specified later in this chapter.
Attractions Data	A data file in dBASE III or IV format that contains one or more attraction variables for each trip purpose by traffic zone (*.dbf extension).	This file is referred to as the attractions file. It should also include a column of data known as the zonal constants. See below for further explanation. Table B.2 is an example of such a data set.
Zonal Constant	A column in the attractions data file.	This data is used in the spatial aggregation process. It is a ratio of the population of the zone to the population of the zone with the smallest population. See Chapter 1 for more information about how this value is used.
Impedance Data	A data file in dBASE III or IV format that contains impedance variables between each zone for all the traffic zones being analyzed (*.dbf extension).	Each field in this file, hereby referred to as the impedance file, is dependent on the mode and the time of day during which the trip is made. Minimum impedance data requirement for a mode and time of day is a field for in-vehicle travel time (IVTT), out-of-vehicle travel time (OVTT) or cost of traveling between the pair of zones. Inclusion of all three provides more robust results. If data are not available for a mode or time of day, it need not be provided. However, to obtain meaningful results from the accessibility computation, it is necessary to have data for at least one mode and one time of day. An example impedance table is presented in Table B.3.
Attractions Parameter	A value unique to a trip purpose.	This parameter is used in the computation of the most disaggregate accessibility value. It can be derived from mode-choice modeling by knowledgeable users. Default values are provided for the purposes of work, shopping, and social-recreation.
Impedance Parameter	Four values unique to a mode. One value is related to the mode itself. For automobile travel there are separate parameters related to in-vehicle-travel-time, out-of-vehicle-travel-time, and cost.	This parameter is used in the computation of the most disaggregate accessibility value. It can be derived from mode-choice modeling by knowledgeable users. Default values are provided.

*Table B.2 Sample Attraction Data Table for Input*

ORIG_ZON	BASIC_EM	RETAILEM	SERVE_EM	PARKSPC	EXPCONST
1	0	0	0		
4	148	107	113	0.00	26055.65
5	239	172	185	0.00	36152.14
7	168	127	136	173.50	26494.62
8	149	123	134	2218.70	17715.06
9	0	0	0	0.00	17689.24
10	120	97	139	0.00	59469.63
11	438	341	369	2.90	59056.47
12	22	20	14	0.00	8264.12
13	343	317	223	16.30	45964.60
...	...	...	...	...	...

In the table shown above:

- ORIG\_ZON – Identity field for each traffic zone,
- BASIC\_EM – Basic employment in the zone, one of the attraction variable for work trips,
- RETAILEM – Retail employment in the zone, one of the attraction variables for work trips and an attraction variable for shopping trips,
- SERVE\_EM – service employment in the zone, one of the attraction variables for work trips,
- PARKSPC – park space in acres, the attraction variable for social-recreational trips, and
- EXPCONST – the constant estimated by the mode-choice model for each zone (default values are provided if needed).

Since accessibility is dimensionless the data for the attractions variable is not restricted to the samples provided here. Users may choose to use alternate measures of attractiveness such as volume of sales or floor space. Be aware of compatibility across groups since, in the example provided here, shopping is a subset of work as a trip purpose. In this case shopping and work variables are all in the same units – number of jobs.

The user’s input file of attraction variables must closely follow the above format. The required fields in this table are:

- Zone ID field (ORIG\_ZON in Table B.2).
- At least one attraction variable field for every trip purpose to be considered in the analysis.

Table B.3 Sample Impedance Data Table for Input

ORIG_ZON	DEST_ZON	COST_OP	TIME_OP	COST_PK	TIME_PK	OVRTT
1	1	0	4.47	0	5.49	3.00
1	2	0	15.62	0	15.98	3.00
1	3	0	26.64	0	29.51	3.00
1	4	0	25.08	0	31.16	3.00
1	5	0	13.48	0	18.67	3.00
1	6	0	16.08	0	17.87	3.00
1	7	0	21.33	0	24.93	3.00
1	8	0	20.61	0	25.21	3.00
1	9	0	15.57	0	17.63	3.00
1	10	0	13.83	0	16.03	3.00
...	...	...	...	...	...	...

In the table shown above:

- ORIG\_ZON – the originating zone from where impedance variables are measured,
- DEST\_ZON – the destination zone to which impedance variables are measured,
- COST\_OP – cost of travel between each pair of zones during off-peak hours,
- TIME\_OP – IVTT between each pair of zones during off-peak hours,
- COST\_PK – cost of travel between each pair of zones during peak hours,
- TIME\_PK – IVTT between each pair of zones during peak hours, and
- OVRTT – OVRTT for all modes and times of day.

The table contains data for only one mode and for two times of day. The fields ORIG\_ZON and DEST\_ZON identify each row of the table uniquely and represent a zonal pair between which all parameters are measured. All combinations of origin and destination zones must be represented for the accessibility computation to be accurate for all zones. The required fields in this table are:

- origin zone ID field (ORIG\_ZON in Table B.3),
- destination zone ID (DEST\_ZON in Table B.3), and
- at least one impedance field.

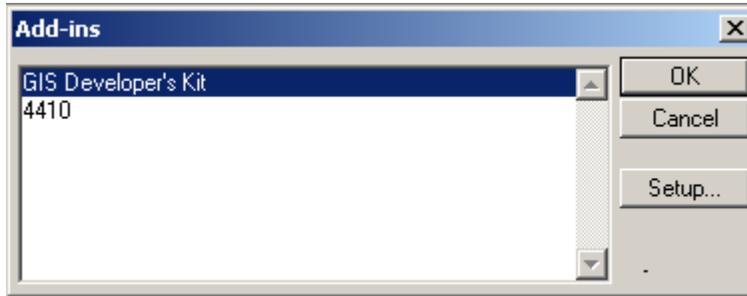
## Installation

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The software requires TransCAD version 4.0 or above to run.

1. Run the self-extracting acc\_software.exe file from the CD.
2. Choose “c:\” as your **Unzip To** folder.
3. The data files associated with the program will locate themselves in **c:\accessibility\data**.
4. The software source code will locate itself in **c:\accessibility/source**.
5. Open TransCAD and click on **Tools-Add-Ins**.

6. Choose **GIS Developer's Kit** (GISDK). Click **OK**.



7. In the GISDK Toolbox choose **Compile to UI**.
8. Navigate to the folder **c:\accessibility\source** and select **acc\_code.rsc**.
9. Click **Open**.
10. When prompted for the interface name, navigate to *c:\accessibility\source* and type *accessibility*. Click **Save**.
11. Go to **Tools -> Add-Ins** and click on **Setup....**
12. Click on **Add** and in the Settings area:
  - a. Choose *Macro* radio button
  - b. In the **Description** box, type *"Urban Accessibility Index"*
  - c. In the **Name** box, type *"Accessibility"*
  - d. In the **UI Database** box, type *"c:\accessibility\source\accessibility"*
  - e. Click **OK**
13. *"Urban Accessibility Index"* will be added to your **Add-Ins** box.
14. To install the Map Compare macro follow Step 12 and type *"Map Compare"* for the **Description** and *"MapCompare"* (note: no space) for the **Name**.

## Directories

Certain directories have to be present or should be created in the local drive c: for the program to run without error. When the self-extracting installation file is run it should automatically create the following directories.

- **c:\accessibility**
- **c:\accessibility\data**
- **c:\accessibility\source**

Verify that these directories have been created after installation. Also, for built-in data sets, verify that all the files described in Chapter 1 are present in the directory **c:\accessibility\data**. Temporary and output data files are created in **c:\accessibility**.

### **Uploading User-Provided Data Files**

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When uploading new input files for custom runs, here are a few guidelines.

- Create a sub-directory under **c:\accessibility** and give it the name of the region to which the data belongs.
- Upload all files to this sub-folder.
- It is not imperative that the input files should be in such a location, they can be present anywhere on the computer, however all output files will be directed to **c:\accessibility**.

### **Saving Output Files**

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The software will produce a color-coded theme map displaying the accessibility of the geographic region under analysis and a raw tabular output showing the accessibility measure value for each traffic zone. Here are a few tips to make it easier to manage output files.

- Do not save the map file directly. Always choose **File – Save As** and give the map file a new name and preferably a new directory. Subsequent color-coded theme maps will not be accurate if the initial map file is saved over.
- If you accidentally save on top of the map file, reload the original map file from backup or the installation disk onto the same directory.
- The same holds for the tabular output, although just choosing **File – Save** will not hinder subsequent runs, the data will be lost the next time the program is run.
- Save the tabular output as .dbf files in other directories. They are needed to obtain graphical comparisons from different runs using the Map Comparison macro.

### **Starting the Program**

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If you are running the program with custom data, ensure that the necessary files are uploaded and are in the correct format. Refer to Table B.1 above for detailed format requirements. The following directions describe how to start the program.

Step 2-1. Open TransCAD

Step 2-2. Click on **Tools – Add-Ins**

Step 2-3. Click on “*Urban Accessibility Index.*”

Step 2-4. Click **OK**.

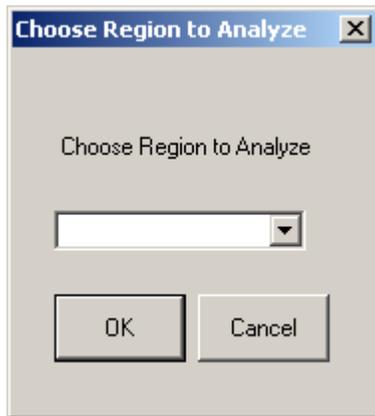
The program is now ready to run. See Chapter 3 for information about how to perform runs using the built-in data sets. Chapters 4 – 19 provide step-by-step instructions for runs with user-provided data. And Chapters 20 and 21 describe some ways to use the output data. It is recommended that all first-time users of the program review the steps in Chapter 3 to familiarize themselves with the program.

### 3. Runs for the Built-In Data Sets

The software comes with a high ease of use for runs using built-in data. The first data set installed is for the Dallas/Fort Worth area from 1995 and will be used as the example in the following steps. Built-in data can be used for runs at any level of aggregation. The data sets come with the software package. To work with the Austin data, choose **Other** in Step 3-1 and when prompted navigate to the Austin files in **c:\accessibility\data**. The Austin files are listed in Chapter 2.

#### Step 3-1. Choose Region to Analyze

Select Dallas-Fort Worth in the drop-down menu. Click **OK** or Press **Enter**.



#### Step 3-2. Choose Level of Aggregation Desired

Choose the aggregation level for which you would like to run the program, from the drop-down menu. Click **OK**.

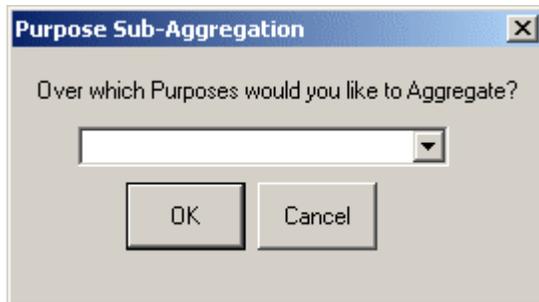


### Step 3-3. Choose Purpose

**No aggregation across trip purposes:** If you chose an aggregation level that does not aggregate purposes, select the trip purpose for which you would like to run the program from the Choose Purpose drop-down menu. Click **OK**.

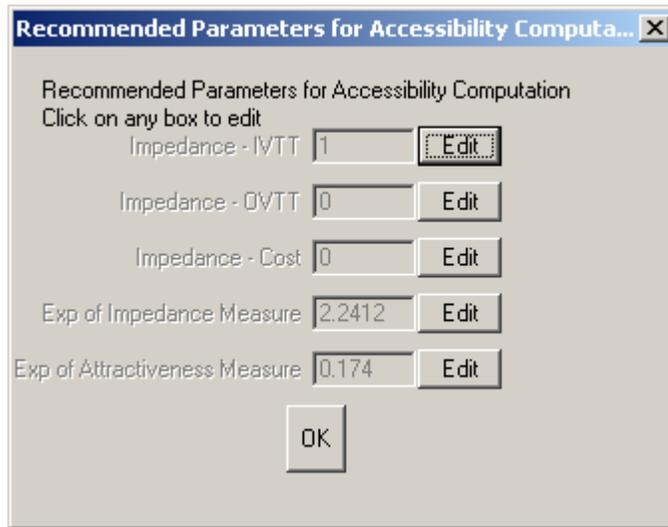


**Aggregation across trip purposes:** If you are aggregating across purposes, dialog box below will appear instead of the dialog box shown above. Select the number of trip purposes over which you would like to aggregate from the Purpose Sub-Aggregation drop-down menu. Click **OK**.



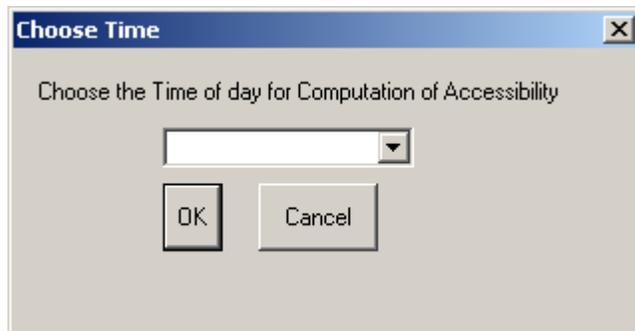
### Step 3-4. Recommended Parameters for Accessibility Computation

The recommended parameters are provided in the box. You can change the values by clicking on the **Edit** button. The default values have been calculated from model estimations for Dallas/Fort Worth and should only be changed with an understanding of the ramifications of these changes. Read Chapters 1 and 2 before making any changes to these values. Click **OK**.



### Step 3-5. Choose Time

**No aggregation across times of day:** If you choose an aggregation level that does not aggregate across times of day, choose a time of day from the dialog box. Click **OK**.



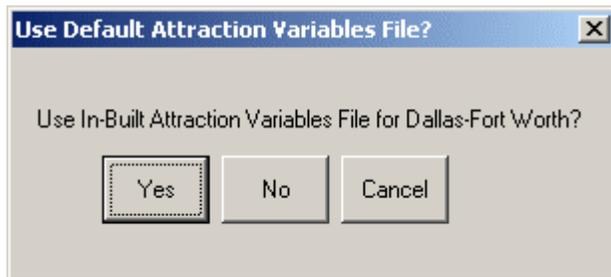
**Aggregation across traffic zones:** If you chose an aggregation level that aggregates across traffic zones, choose the zonal unit to which you would like to aggregate in the

Zonal Aggregation Level drop-down menu. Click **OK**.



**Step 3-6. Use Default Attraction Variables File**

Click on **Yes** in the dialog box.



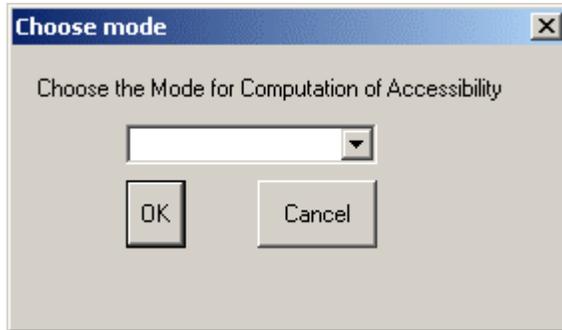
**Step 3-7. Use Default Impedance File**

Click on **Yes** in the dialog box.



### Step 3-8. Choose Mode

**No aggregation across modes:** If you chose an aggregation level that does not aggregate across modes, choose a mode of travel in the drop-down menu. Click **OK**.



Give the program up to 45 minutes depending on the level of aggregation to produce a map and table as output. For options on how to manipulate output, see chapter 20.

**Note:** TransCAD may appear as *Not responding* in the Task Menu. Please do not end the TransCAD session in this case. A result will be produced after the program is finished running.



## 4. No Aggregation (Disaggregate) Run

The following chapters guide you on how to use the software for data sets that do not come with the software package. The location and format of these data sets should strictly adhere to the guidelines outlined in Chapter 2 of this manual. This run computes accessibility for the most disaggregate level of trip purpose, mode, time of day, and traffic zone.

### For User-Provided Data

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#### Step 4-1. Level of Aggregation

After selecting a region, choose **No Aggregation** in the dialog box and click **OK**.

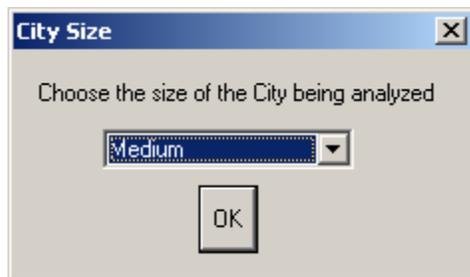
#### Step 4-2. Choose Purpose

Select a trip purpose from the drop-down menu. Click **OK**.



#### Step 4-3. City Size

Select the size of the city being considered from the drop-down menu. Click **OK**.

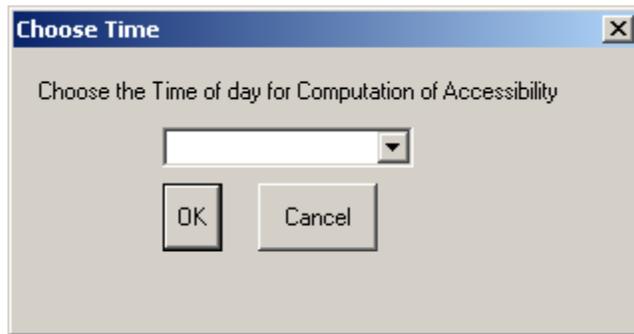


#### Step 4-4. Recommended Parameters

Based on the city size chosen, the software will display the parameters that it recommends for the accessibility run. Refer to step 3-4 before making any changes. Click **OK**.

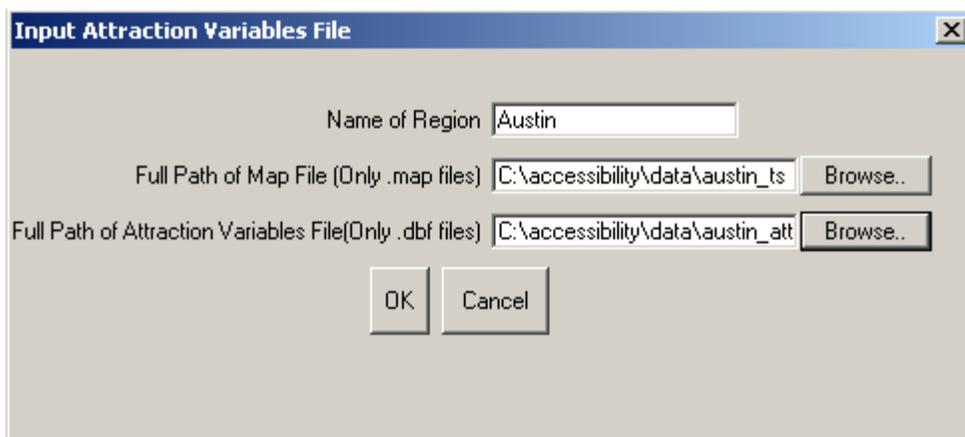
#### Step 4-5. Choose Time

Select a time of day for the run from the drop-down menu. Click **OK**.



#### Step 4-6. Input Attraction Variables File

In the dialog box, enter the name of the region. Enter the full directory location path of the TransCAD map file in the **Full Path of Map file** text box. Click on **Browse** to navigate to the file and choose **OK**.



**Note:** Ensure that all the associated files to the .map file reside in the same directory as the file itself.

Enter the full directory location path of the dBASE IV file that holds the attraction data for each traffic zone for the region under analysis in the **Full Path of Attraction Variables File** text box. Click on **Browse** to navigate to the file and choose **OK**.

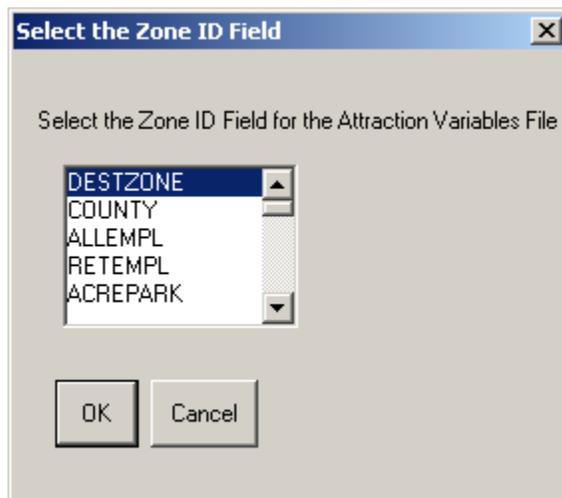
#### Step 4-7. Zone Designation Field

Select the field that designates traffic zones (the zone being used for this run) in the dataview associated with the map layer for the region. Click **OK**.



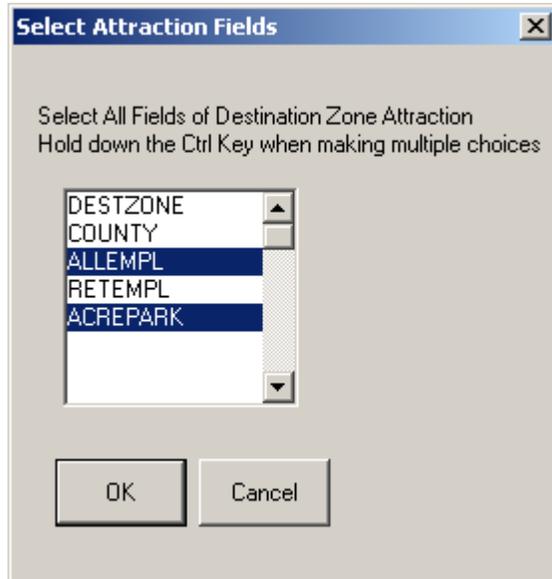
#### Step 4-8. Zone ID Field

Select the field that designates the same traffic zone referred to in step 4-7 above in the Attraction Variables File. Click **OK**.



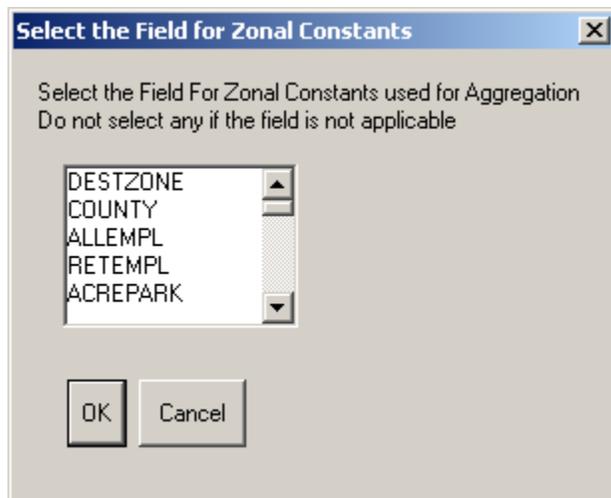
#### Step 4-9. Select Attraction Fields

Select all fields that need to be summed to obtain the total attraction of each destination zone for the trip purpose under consideration from the scroll list. Click **OK**.



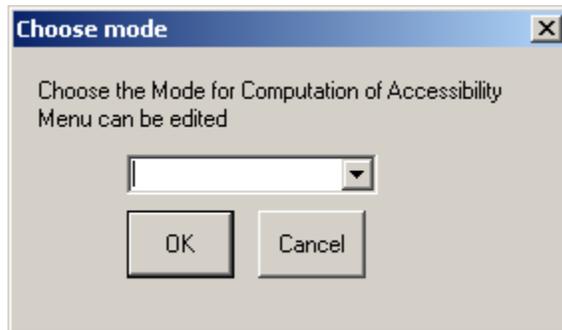
#### Step 4-10. Zonal Constants

Select the field that designates the constant multiplier for each destination zone for the region. These constants are only used for aggregation runs. For further explanation of zonal constants please refer to Chapter 2.



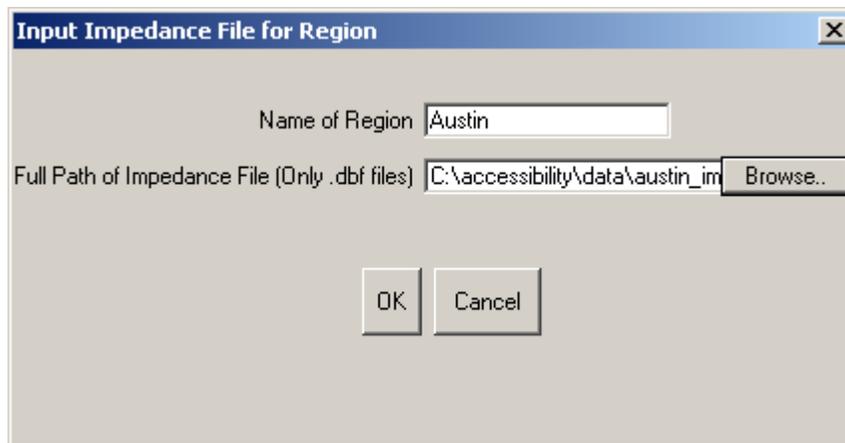
### Step 4-11. Choose Mode

Select or **enter** a mode name from the editable drop-down menu.



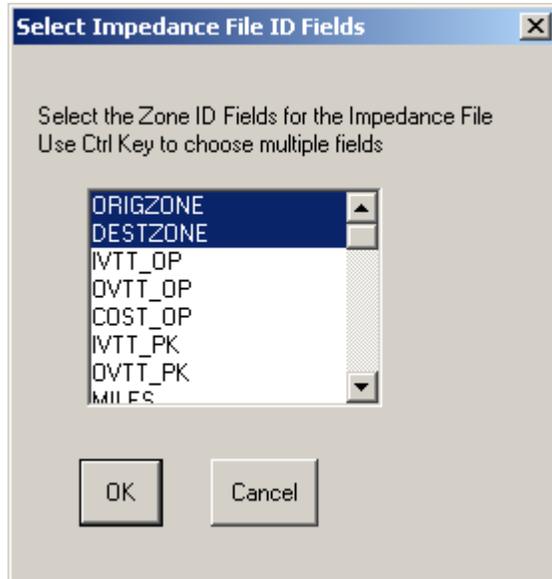
### Step 4-12. Input Impedance File

Enter the full path of the impedance variables file for the region being analyzed. Click on **Browse**, navigate to the file and click **OK**.



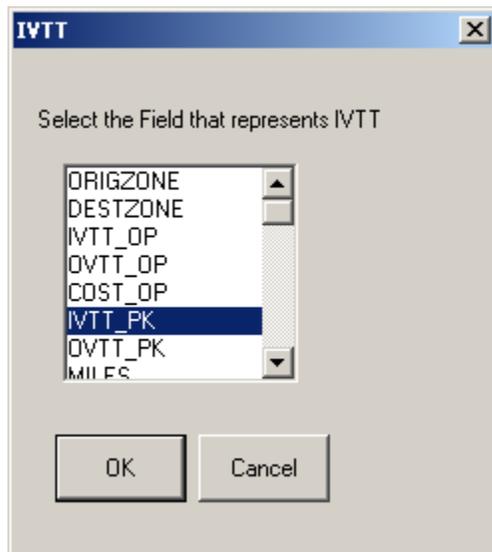
#### Step 4-13. Select Impedance File ID Fields

Select the fields that designate the origin traffic zone and the destination traffic zone in the impedance variables file from the scroll list. Click **OK**.



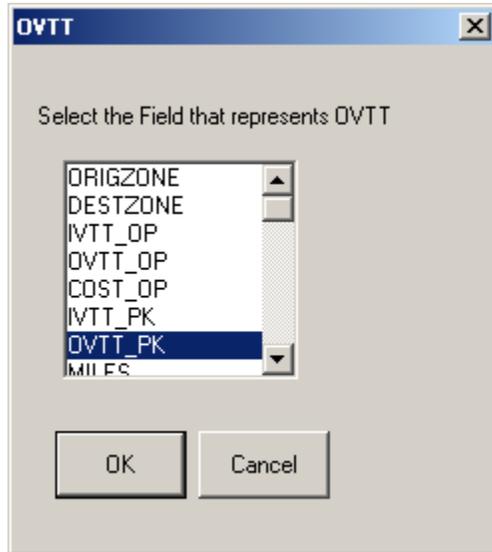
#### Step 4-14. IVTT

Select the field in the impedance variables file that designates IVTT for the mode and time of day used in this run from the scroll list. Click **OK**.



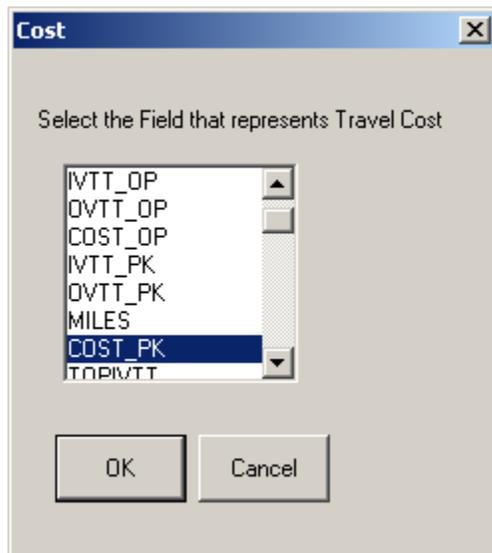
#### Step 4-15. OVTT

Select the field in the impedance variables file that designates OVTT for the mode and time of day used in this run from the scroll list. Click **OK**.



#### Step 4-16. Cost

Select the field in the impedance variables file that designates cost for the mode and time of day used in this run from the **Cost** scroll list. Click **OK**.



Depending on the size of the data files being processed the program can take up to 45 minutes to produce an output.

**Note:** TransCAD may appear as *Not responding* in the Task Menu. Please do not end the TransCAD session in this case. A result will be produced after the program is finished running.

## 5. Mode Only Aggregation Run

The equation used for mode only aggregation is:

$$Acc_{ipt} = \ln \left[ \frac{1}{M} \sum_{j=1}^M \frac{\left\{ A_{impt} \times e^{\alpha_m} + A_{inpt} \times e^{\alpha_n} \right\}}{\left\{ e^{\alpha_m} + e^{\alpha_n} \right\}} \right]$$

where:

$Acc_{ipt}$  = Accessibility for zone i, trip purpose p, and time of day t aggregated across both modes m and n.

M = Total number of modes (in this case = 2)

$A_{impt}$  = Accessibility for zone i, trip purpose p, time of day t and mode m.

$A_{inpt}$  = Accessibility for zone i, trip purpose p, time of day t and mode n.

$\alpha_m$  = Constant associated with mode m, computed from the fraction of trips made using modes m and n in the region under consideration. This is used to weight the aggregate accessibility.

$\alpha_n$  = Constant for mode n.

**For Built-In Data** – Please refer to Chapter3.

**For User-Provided Data**

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### Step 5-1. Level of Aggregation

After selecting a region, choose **Mode Only** in the Level of Aggregation dialog box and click **OK**.

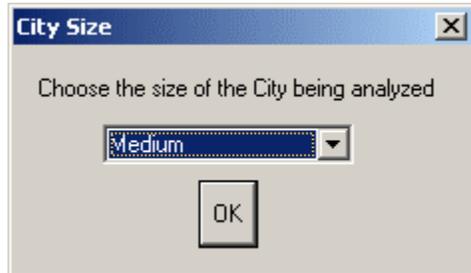
### Step 5-2. Choose Purpose

Choose a Trip Purpose from the drop-down menu. Click **OK**.



### Step 5-3. City Size

Choose the size of the city being analyzed from the drop-down menu. The parameters recommended for the run will be decided based on this response. Click **OK**.

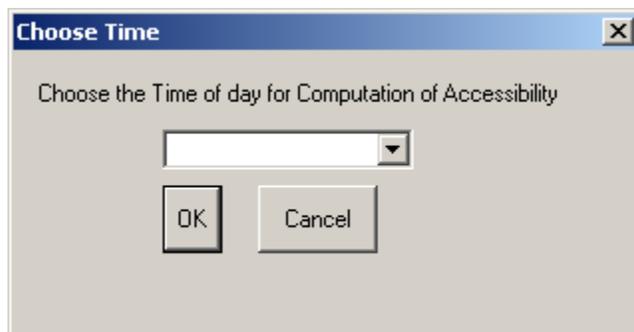


### Step 5-4. Recommended Parameters

The software will display the parameters that it recommends for the accessibility run. A detailed explanation of this dialog box is in step 3-4. Please refer to that and make any necessary changes before clicking **OK**.

### Step 5-5. Choose Time

Select a time of day for the run from the drop-down menu. Click **OK**.

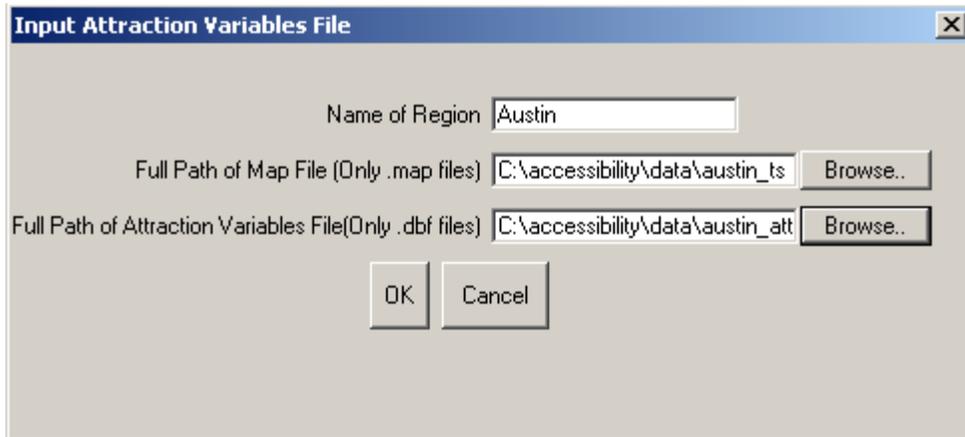


### Step 5-6. Input Attraction Variables File

In the dialog box, enter the name of the region. Enter the full directory location path of the TransCAD map file in the **Full Path of Map file** text box. Click on **Browse** to navigate to the file and choose **OK**.

**Note:** Ensure that all the associated files to the .map file reside in the same directory as the file itself.

Enter the full directory location path of the dBASE IV file that holds the attraction data for each traffic zone for the region under analysis in the **Full path of attraction variables file** textbox. Click on **Browse** to navigate to the file and choose **OK**.



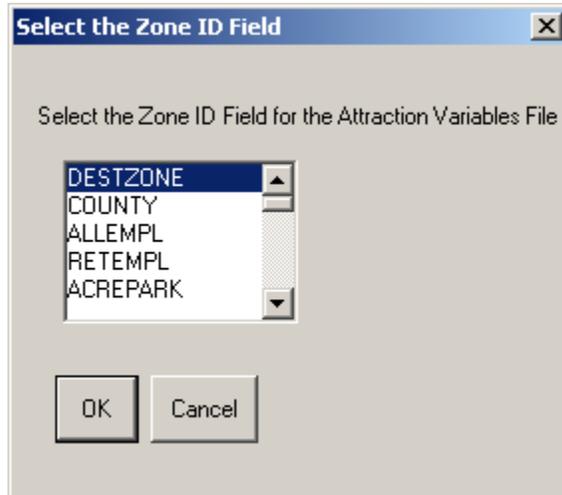
#### Step 5-7. Zone Designation

Select the field that designates traffic zones (the zone being used for this run) in the dataview associated with the map layer for the region. Click **OK**.



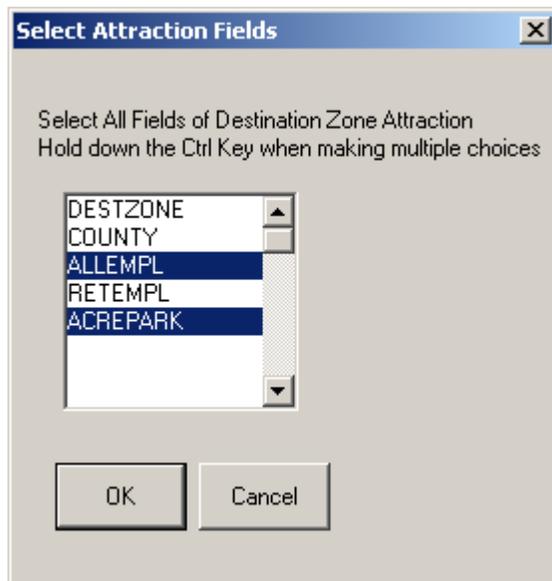
### Step 5-8. Zone ID Field

Select the field that designates the same traffic zone referred to in step 5-7 above in the Attraction Variables File. Click **OK**.



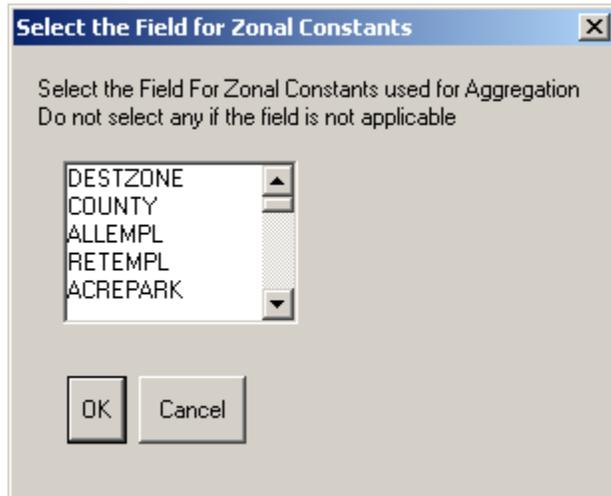
### Step 5-9. Select Attraction Fields

Select all fields that need to be summed to obtain the total attraction of each destination zone for the trip purpose under consideration from the scroll list. Click **OK**.



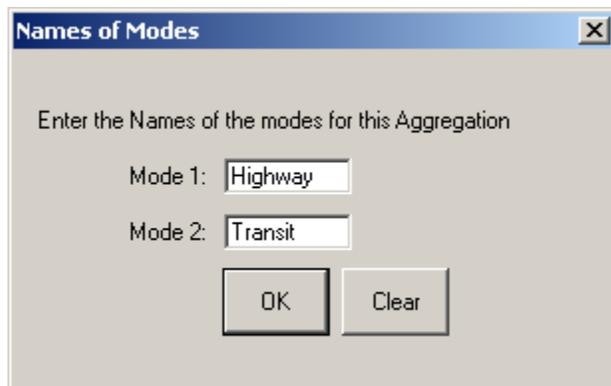
### Step 5-10. Zonal Constants

Select the field that designates the constant multiplier for each destination zone for the region. These constants are only used for aggregation runs. For further explanation of zonal constants please refer to Chapter 2.



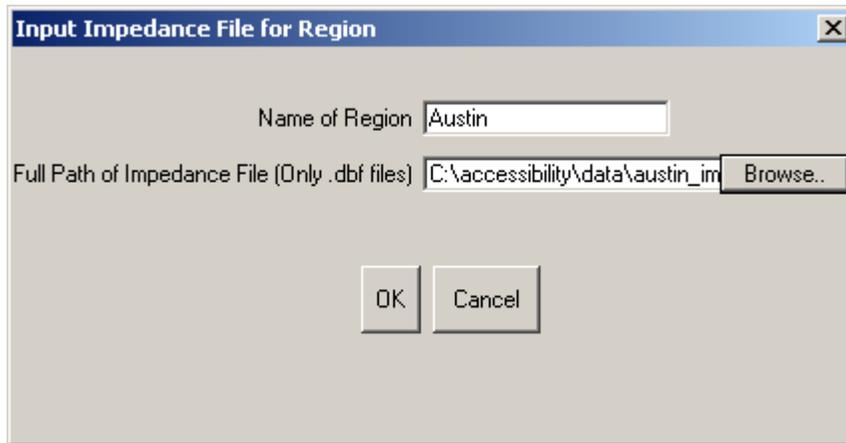
### Step 5-11. Mode Names

Enter the names of the two modes being analyzed in this aggregate run. Click **OK**.



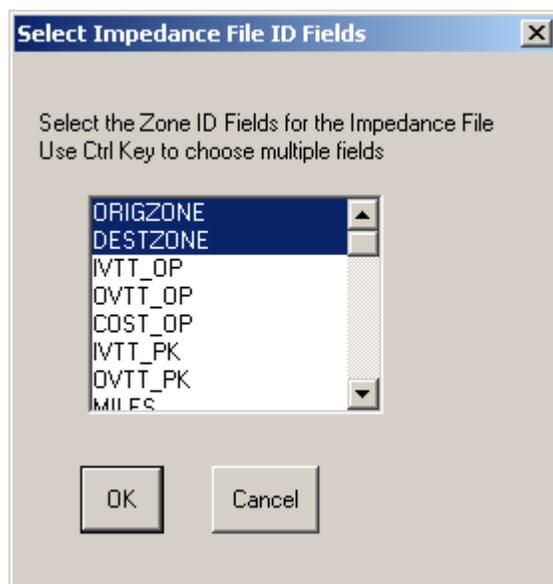
### Step 5-12. Input Impedance File

Enter the full path of the impedance variables file for the region being analyzed. Click on **Browse**, navigate to the file and click **OK**.



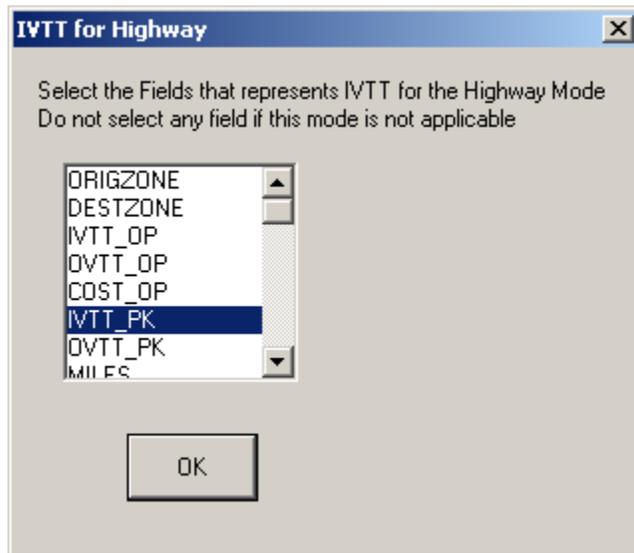
### Step 5-13. Select Impedance File ID Fields

Select the fields that designate the origin traffic zone and the destination traffic zone in the Impedance Variables file from the scroll list. Click **OK**.



### Step 5-14. IVTT

Select the field in the impedance variables file that represents IVTT for the mode selected in the box and the time of day for which this run is being made. For example, in the figure shown below **IVTT\_PK** is the field that represents IVTT for the Highway mode for the time of day under analysis which is peak. Click **OK**.



### Step 5-15. OVTT

Select the field in the impedance variables file that represents OVTT for the mode shown in the box and the time of day for which this run is being made. For example, in the figure shown below **OVTT\_PK** is the field that represents OVTT for the Highway mode for the time of day under analysis which is peak. Click **OK**.



### Step 5-16. Cost

Select the field in the impedance variables file that represents travel cost for the mode mentioned in the box and the time of day for which this run is being made. For example, in the figure shown below **COST\_PK** is the field that represents Cost for the Highway mode for the time of day under analysis which is peak. Click **OK**.

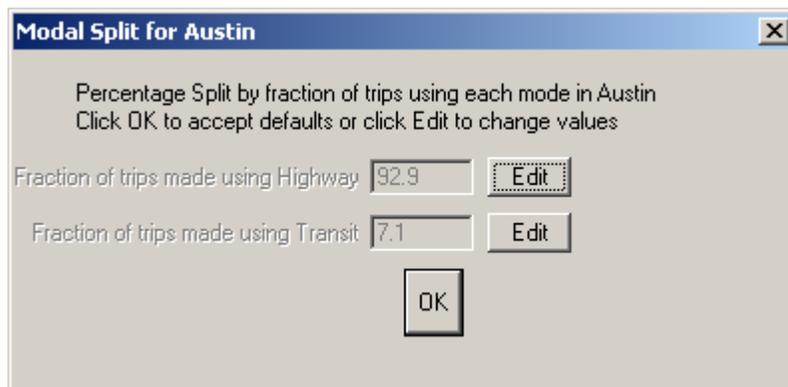


### Steps 5-17 – 5-19. IVTT, OVTT, and Cost for Mode 2

Repeat steps 5-14 – 5-16 for the second mode.

### Step 5- 20. Modal Split

To compute aggregate accessibility across modes, the software requires the percentage of trips made using each mode in the region. The default values provided are based on current data for Austin (an example of a medium size city in Texas) and Dallas/Fort Worth (an example of a large city in Texas). Click on **Edit** to alter values if these are available for the city under consideration. Click **OK**.



Depending on the size of the data files being processed the program can take up to 45 minutes to produce an output.

**Note:** TransCAD may appear as *Not responding* in the Task Menu. Please do not end the TransCAD session in this case. A result will be produced after the program is finished running.



## 6. Trip Purpose Only Aggregation Run

The equation used for purpose only aggregation:

$$Acc_{imt} = \ln \left[ \frac{1}{P} \sum_{j=1}^P \frac{\left\{ A_{imot} \times e^{\alpha_o} + A_{impt} \times e^{\alpha_p} + A_{imqt} \times e^{\alpha_q} \right\}}{\left\{ e^{\alpha_m} + e^{\alpha_n} + e^{\alpha_q} \right\}} \right]$$

where:

$Acc_{imt}$  = Accessibility for zone i, mode m, and time of day t aggregated across all purposes.

P = Total number of purposes (in this case = 3)

$A_{imot}$  = Accessibility for zone i, mode m, time of day t and trip purpose o.

$A_{impt}$  = Accessibility for zone i, mode m, time of day t and trip purpose p.

$A_{imqt}$  = Accessibility for zone i, mode m, time of day t and trip purpose q.

$\alpha_o$  = Constant associated with trip purpose o, computed from the fraction of trips made for all purposes in the region under consideration. This is used to weight the aggregate accessibility.

$\alpha_p$  = Constant for purpose p.

$\alpha_q$  = Constant for purpose q.

**For Built-In Data** – Please refer to Chapter 3.

**For User-Provided Data**

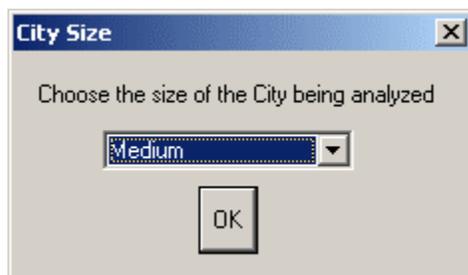
---

### Step 6-1. Level of Aggregation

After selecting a region, choose **Trip Purpose Only** in the dialog box and click **OK**.

### Step 6-2. City Size

Choose the size of the city being analyzed from the drop-down menu. The parameters recommended for the run will be decided based on this response. Click **OK**.

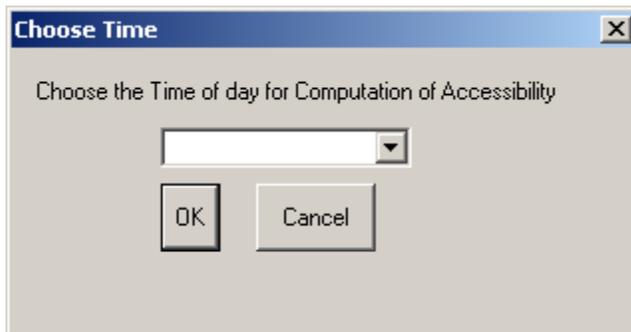


### Step 6-3. Recommended Parameters

The software will display the parameters that it recommends for the accessibility run. A detailed explanation of this dialog box is in step 3-4. Please refer to that and make any necessary changes before clicking **OK**.

### Step 6-4. Choose Time

Select a time of day for the run from the drop-down menu. Click **OK**.

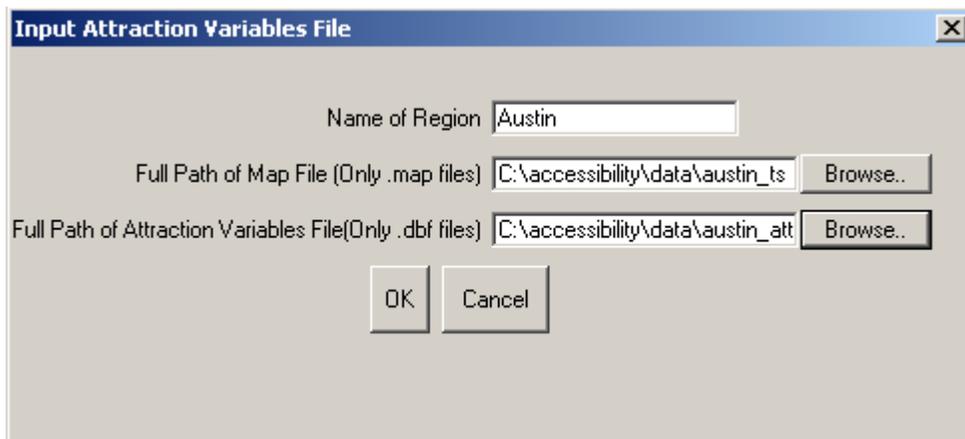


### Step 6-5. Input Attraction Variables File

In the dialog box, enter the **name of the region**. Enter the **full directory location path** of the TransCAD map file in the **Full Path of Map file** text box. Click on **Browse** to navigate to the file and choose **OK**.

**Note:** Ensure that all the associated files to the .map file reside in the same directory as the file itself.

Enter the **full directory location path** of the dBASE IV file that holds the attraction data for each traffic zone for the region under analysis in the **Full path of attraction variables file** textbox. Click on **Browse** to navigate to the file and choose **OK**.



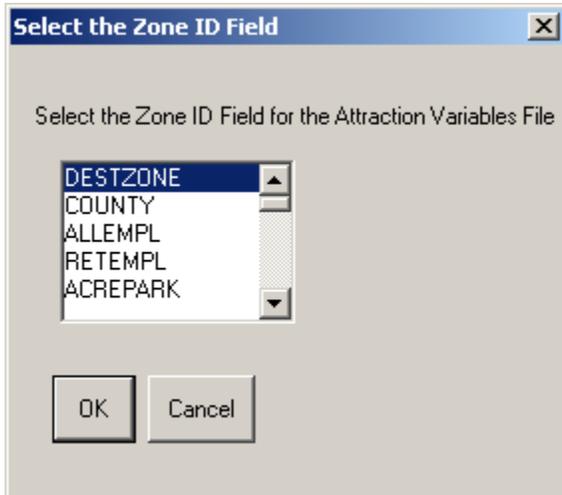
### Step 6-6. Zone Designation

Select the field that designates **traffic zones** (the zone being used for this run) in the dataview associated with the map layer for the region. Click **OK**.



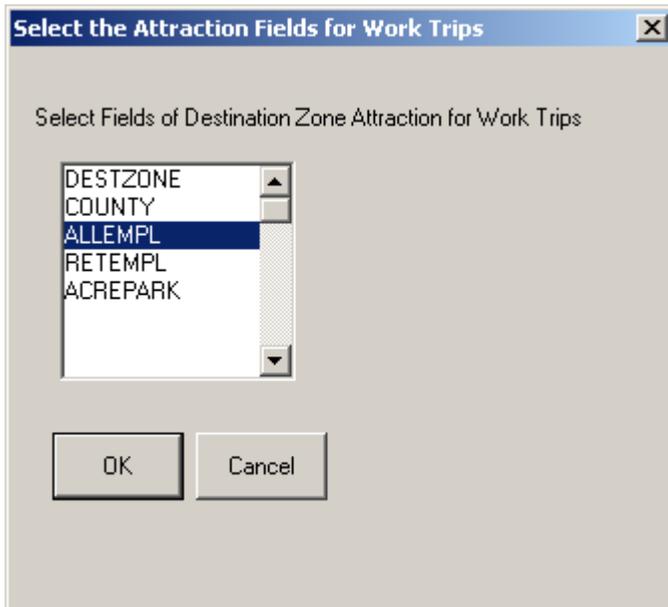
### Step 6-7. Zone ID Field

Select the field that designates the same **traffic zone** referred to in step 6-5 above in the Attraction Variables File. Click **OK**.



### Step 6-8. Select the Attraction Fields for Work Trips

Select all fields that need to be summed to obtain the total attraction of each destination zone for *Work trips* from the scroll list. Click **OK**.



**Step 6-9. Select the Attraction Fields for Social Trips**

Select all fields that need to be summed to obtain the total attraction of each destination zone for *Social-Recreational trips* from the scroll list. Click **OK**.



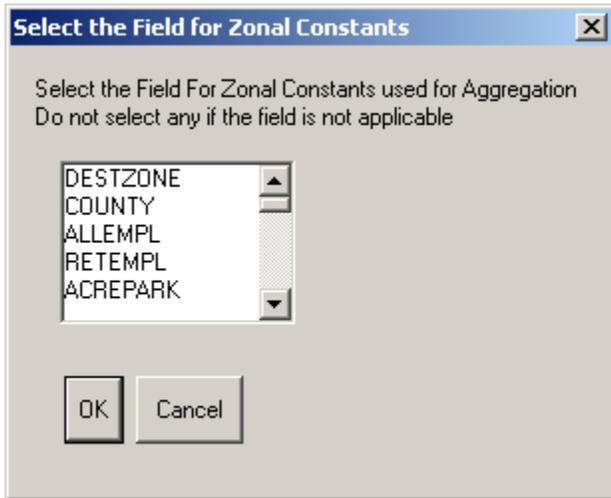
**Step 6-10. Select Attraction Fields for Shopping Trips**

Select all fields that need to be summed to obtain the total attraction of each destination zone for *Shopping trips* from the scroll list. Click **OK**.



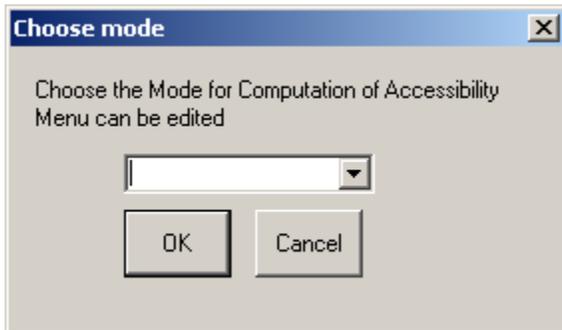
### Step 6-11. Zonal Constants

Select the field that designates the constant multiplier for each destination zone for the region. These constants are only used for aggregation runs. For further explanation of zonal constants please refer to Chapter 2.



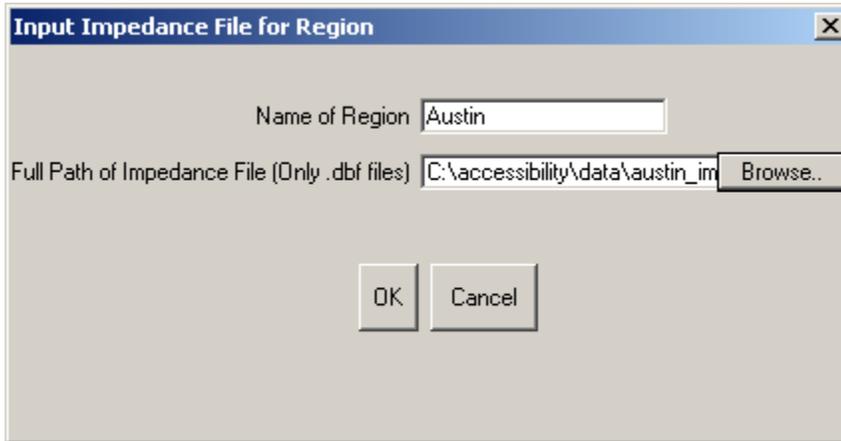
### Step 6-12. Choose Mode

Select or **enter** a mode name from the **editable** drop-down menu.



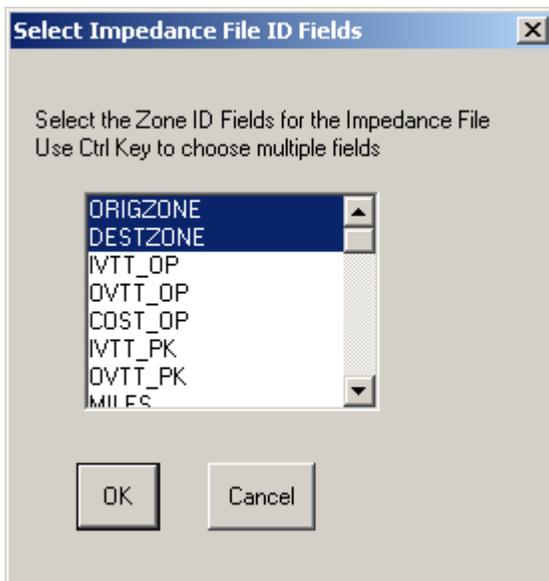
### Step 6-13. Input Impedance File

Enter the full path of the impedance variables file for the region being analyzed. Click on **Browse**, navigate to the file and click **OK**.



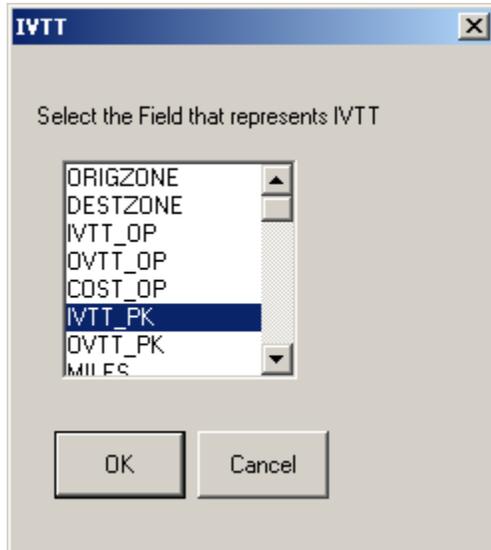
### Step 6-14. Select Impedance File ID Fields

Select the fields that designate the origin traffic zone and the destination traffic zone in the Impedance Variables file from the scroll list. Click **OK**.



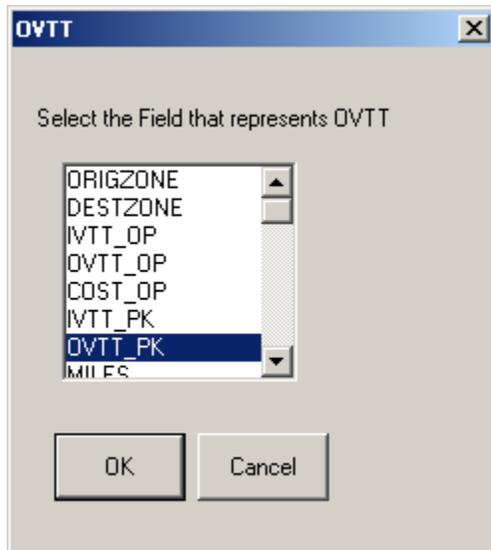
### Step 6-15. IVTT

Select the field in the impedance variables file that designates **IVTT** for the mode and time of day used in this run from the scroll list. Click **OK**.



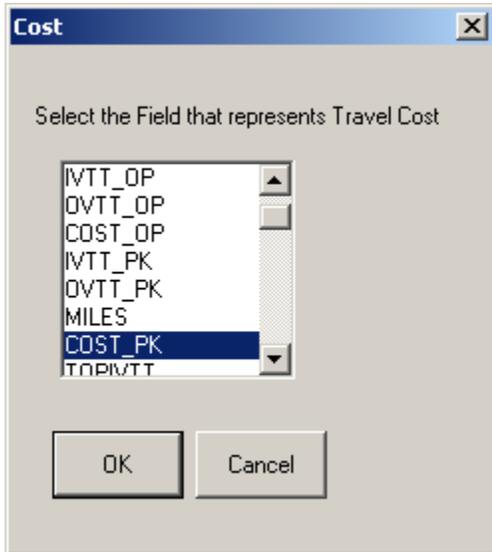
### Step 6-16. OVTT

Select the field in the impedance variables file that designates **OVTT** for the mode and time of day used in this run from the scroll list. Click **OK**.



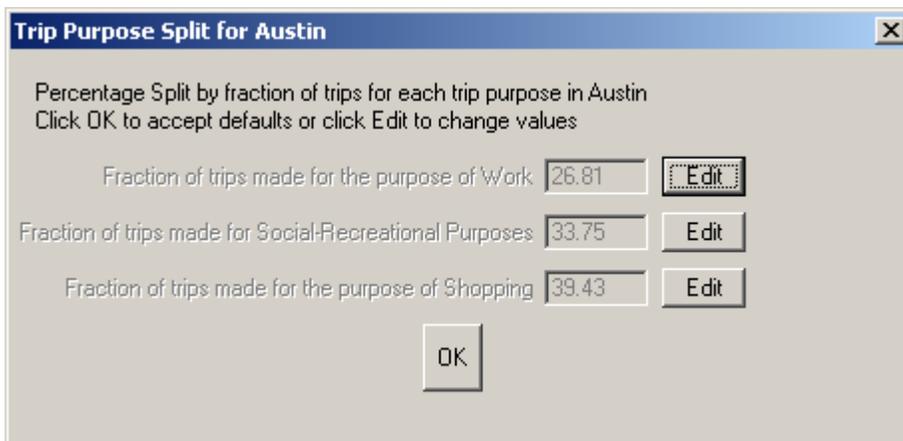
### Step 6-17. Cost

Select the field in the impedance variables file that designates **Cost** for the mode and time of day used in this run from the scroll list. Click **OK**.



### Step 6-18. Trip Purpose Split

To compute aggregate accessibility across purposes, the software requires the percentage of trips made for each purpose in the region. The default values provided are based on current data for Austin (an example of a medium size city in Texas) and Dallas/Fort Worth (an example of a large city in Texas). Click on **Edit** to alter values if these are available for the city under consideration. Click **OK**.



Depending on the size of the data files being processed the program can take up to 45 minutes to produce an output.

**Note:** TransCAD may appear as “*Not responding*” in the Task Menu. Please do not end the TransCAD session in this case. A result will be produced after the program is finished running.

## 7. Time of Day Only Aggregation Run

The equation used for time of day only aggregation is:

$$Acc_{imp} = \ln \left[ \frac{1}{T} \sum_{j=1}^T \frac{\left\{ A_{impt_1} \times e^{\alpha_{t_1}} + A_{impt_2} \times e^{\alpha_{t_2}} + A_{impt_3} \times e^{\alpha_{t_3}} + \dots \right\}}{\left\{ e^{\alpha_{t_1}} + e^{\alpha_{t_2}} + e^{\alpha_{t_3}} + \dots \right\}} \right]$$

where:

$Acc_{imp}$  = Accessibility for zone i, mode m, and purposes p aggregated across all times of day.

T = Total number of time periods.

$\alpha_{t_1}$  = Constant associated with time of day  $t_1$ , computed from the fraction of trips made during time of day  $t_1$  when compared to all the trips made during the day in the region under consideration. This is used to weight the aggregate accessibility.

$\alpha_{t_2}$  = Constant for time of day  $t_2$ .

$\alpha_{t_3}$  = Constant for time of day  $t_3$ .

**For Built-In Data** – Please refer to Chapter 3.

**For User-Provided Data**

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### Step 7-1. Level of Aggregation

After selecting a region, choose **Time of Day Only** in the dialog box and click **OK**.

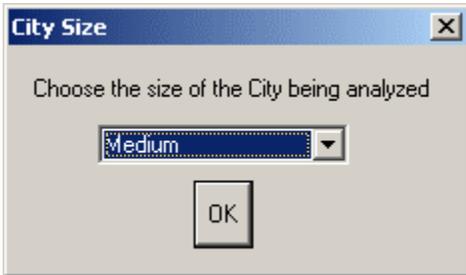
### Step 7-2. Choose Purpose

Choose a Trip Purpose from the drop-down menu.



### Step 7-3. City Size

Choose the size of the city being analyzed from the drop-down menu. The parameters recommended for the run will be decided based on this response. Click **OK**.

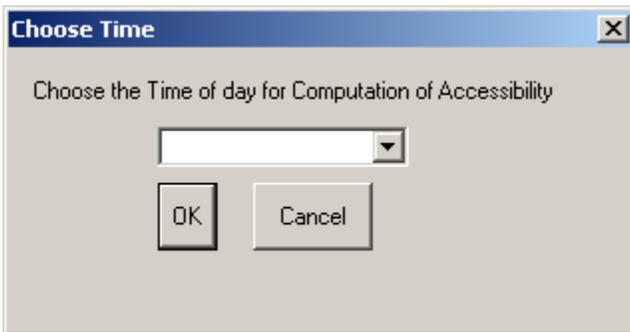


### Step 7-4. Recommended Parameters

The software will display the parameters that it recommends for the accessibility run. A detailed explanation of this dialog box is in step 3-4. Please refer to that and make any necessary changes before clicking **OK**.

### Step 7-5. Choose Time

Select a time of day for the run from the drop-down menu. Click **OK**.

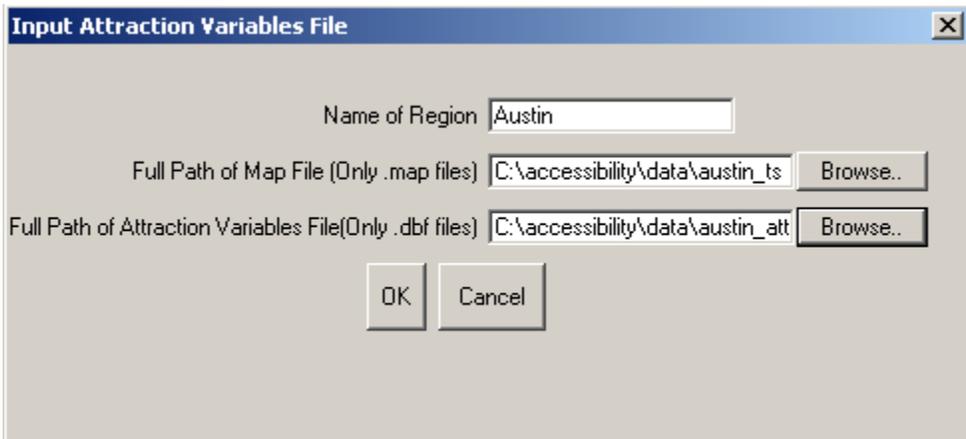


### Step 7-6. Input Attraction Variables File

In the dialog box, enter the **name of the region**. Enter the **full directory location path** of the TransCAD map file in the **Full Path of Map file** text box. Click on **Browse** to navigate to the file and choose **OK**.

**Note:** Ensure that all the associated files to the .map file reside in the same directory as the file itself.

Enter the **full directory location path** of the dBASE IV file that holds the attraction data for each traffic zone for the region under analysis in the **Full path of attraction variables file** textbox. Click on **Browse** to navigate to the file and choose **OK**.



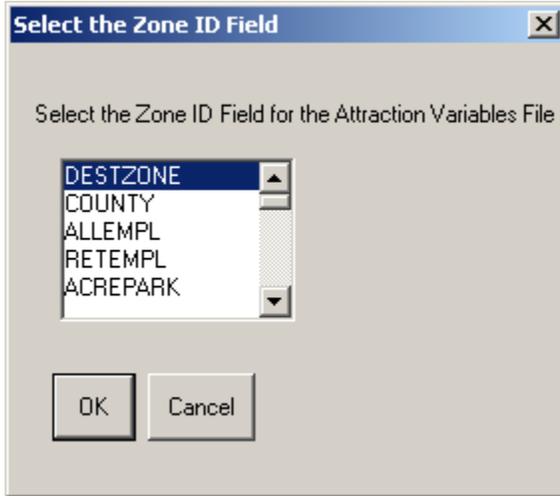
### Step 7-7. Zone Designation

Select the field that designates **traffic zones** (the zone being used for this run) in the dataview associated with the map layer for the region. Click **OK**.



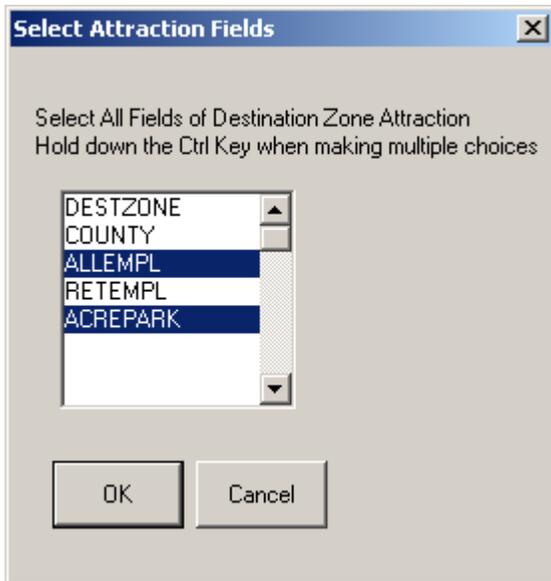
### Step 7-8. Zone ID Field

Select the field that designates the same **traffic zone** referred to in step 7-6 above in the Attraction Variables File. Click **OK**.



### Step 7-9. Select Attraction Fields

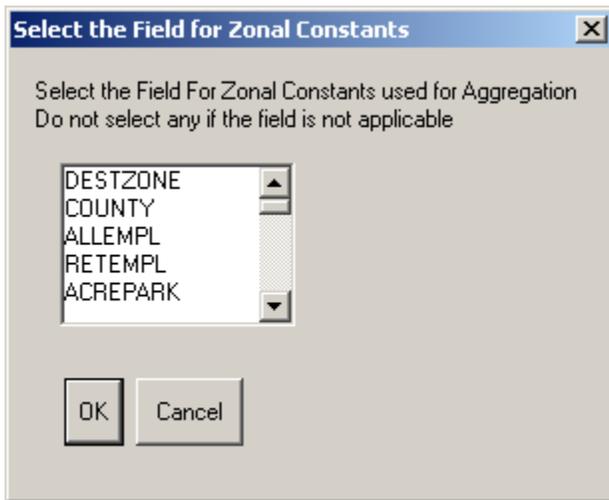
Select all fields that need to be summed to obtain the total attraction of each destination zone for the trip purpose under consideration from the scroll list. Click **OK**.



### Step 7-10. Zonal Constants

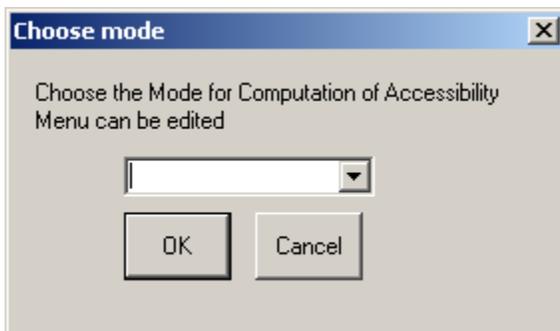
Select the field that designates the constant multiplier for each destination zone for the region. These constants are only used for aggregation runs. For further explanation of

zonal constants please refer to Chapter 2.



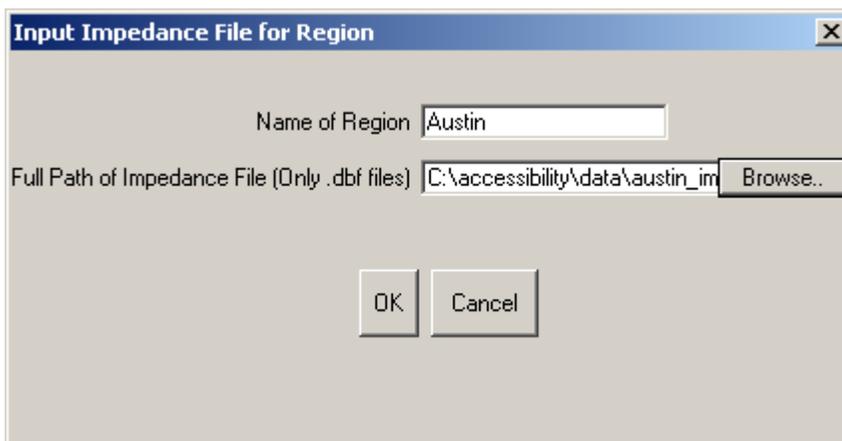
### Step 7-11. Choose Mode

Select or **enter** a mode name from the **editable** drop-down menu.



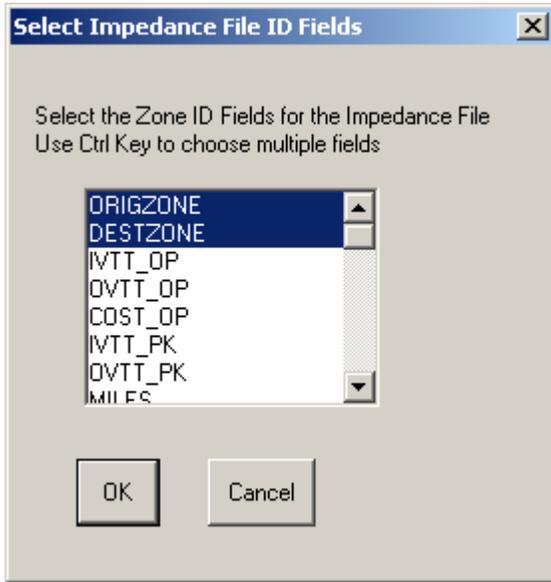
### Step 7-12. Input Impedance File

Enter the full path of the impedance variables file for the region being analyzed. Click on **Browse**, navigate to the file and click **OK**.



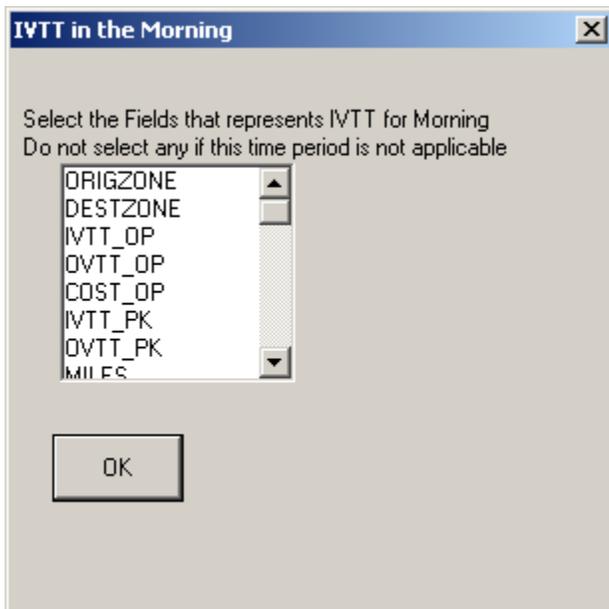
**Step 7-13. Select Impedance File ID Fields**

Select the fields that designate the origin traffic zone and the destination traffic zone in the Impedance Variables file from the scroll list. Click **OK**.



**Step 7-14. IVTT for Time Period**

Select the field that represents **IVTT** for the **Morning** time period. Do not select any field if no data is available for such a time period. Click **OK**.



### Step 7-15. OVTT for Time Period

Select the field that represents **OVTT** for the **Morning** time period. Do not select any field if no data is available for such a time period. Click **OK**.

OVTT for Morning

Select the Fields that represents OVTT for Morning  
Do not select any if this time period is not applicable

- ORIGZONE
- DESTZONE
- IVTT\_OP
- OVTT\_OP
- COST\_OP
- IVTT\_PK
- OVTT\_PK
- MILES

OK

### Step 7-16. Cost for Time Period

Select the field that represents **Cost** for the **Morning** time period. Do not select any field if no data is available for such a time period. Click **OK**.

Cost

Select the Fields that represents Travel Cost for Morning  
Do not select any if this time period is not applicable

- ORIGZONE
- DESTZONE
- IVTT\_OP
- OVTT\_OP
- COST\_OP
- IVTT\_PK
- OVTT\_PK
- MILES

OK

### Steps 7-17 – 7-31. IVTT, OVTT, and Cost for the Time Periods

Repeat Steps 7-14 – 7-16 for each of the time periods.

### Step 7-32. Time of day Split

To compute aggregate accessibility across times of day, the software requires the percentage of trips made during each time period in the region. The default values provided are based on current data for Austin (an example of a medium size city in Texas) and Dallas/Fort Worth (an example of a large city in Texas). Click on **Edit** to alter values if these are available for the city under consideration. Click **OK**.

**Time of Day Split for Austin** [X]

Percentage Split by fraction of trips for each time of day in Austin  
Click OK to accept defaults or click Edit to change values

Fraction of trips made in the Morning	4.07	Edit
Fraction of trips made in the AM Peak Period	20.35	Edit
Fraction of trips made in the AM Off-Peak Period	13.1	Edit
Fraction of trips made in the PM Off-Peak Period	26.3	Edit
Fraction of trips made in the PM Peak Period	20.76	Edit
Fraction of trips made in the Evening	15.47	Edit

OK

Depending on the size of the data files being processed the program can take up to 45 minutes to produce an output.

**Note:** TransCAD may appear as *Not responding* in the Task Menu. Please do not end the TransCAD session in this case. A TransCAD map and dataview will be produced as a result after the program is finished running.

## 8. Zone Only Aggregation Run

The equation used for zone only aggregation is:

$$Acc_{tmp} = \ln \left[ \frac{1}{N} \sum_{j=1}^N \frac{\left\{ A_{i_1, mpt} \times e^{\alpha_{i_1}} + A_{i_2, mpt} \times e^{\alpha_{i_2}} + A_{i_3, mpt} \times e^{\alpha_{i_3}} + \dots \right\}}{\left\{ e^{\alpha_{i_1}} + e^{\alpha_{i_2}} + e^{\alpha_{i_3}} + \dots \right\}} \right]$$

where:

$Acc_{tmp}$  = Accessibility for mode m, time period t and purpose p aggregated across traffic zones.

N = Total number of zones.

$\alpha_{i_1}$  = Constant associated with zone  $i_1$ , computed from the fraction of trips made from zone  $i_1$  when compared to all the trips made from other zones in the region under consideration.

This is used to weight the aggregate accessibility.

$\alpha_{i_2}$  = Constant for zone  $i_2$ .

$\alpha_{i_3}$  = Constant for zone  $i_3$ .

**For Built-In Data** – Please refer to Chapter 3.

**For User-Provided Data**

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### Step 8-1. Choose Level of Aggregation

After selecting a region, choose “**Zone Only**” from the drop-down menu. Click **OK**.

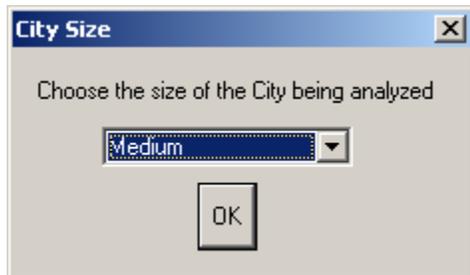
### Step 8-2. Choose Purpose

Select a trip purpose from the drop-down menu. Click **OK**.



### Step 8-3. City Size

Select the size of the city being considered from the drop-down menu. Click **OK**.

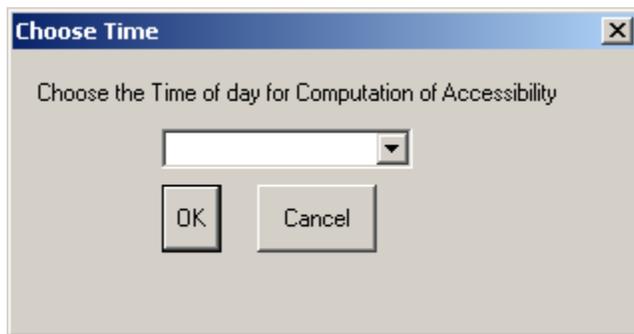


### Step 8-4. Recommended Parameters

Based on the city size chosen, the software will display the parameters that it recommends for the accessibility run. A detailed explanation of this dialog box is in step 3-4. Please refer to that and make any necessary changes before clicking **OK**.

### Step 8.5. Choose Time

Select a time of day for the run from the drop-down menu. Click **OK**.

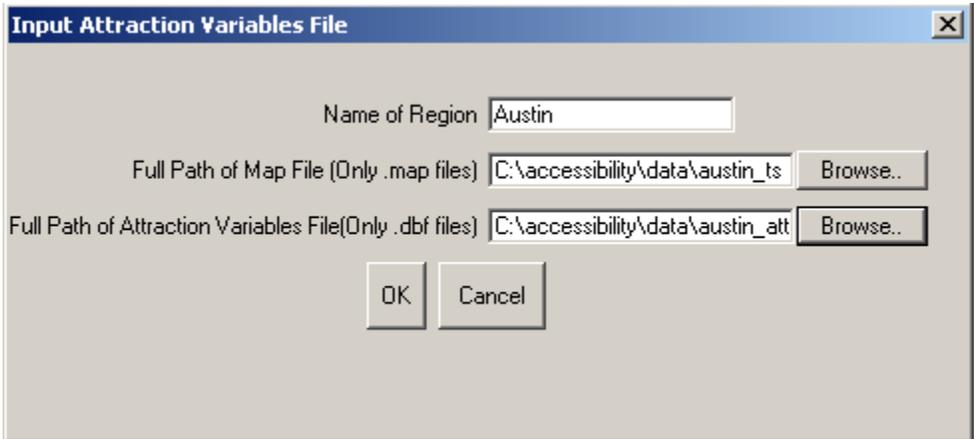


### Step 8-6. Input Attraction Variables File

In the dialog box, enter the **name of the region**. Enter the **full directory location path** of the TransCAD map file in the **Full Path of Map file** text box. Click on **Browse** to navigate to the file and choose **OK**.

**Note:** Ensure that all the associated files to the .map file reside in the same directory as the file itself.

Enter the **full directory location path** of the dBASE IV file that holds the attraction data for each traffic zone for the region under analysis in the **Full path of attraction variables file** text box. Click on **Browse** to navigate to the file and choose **OK**.



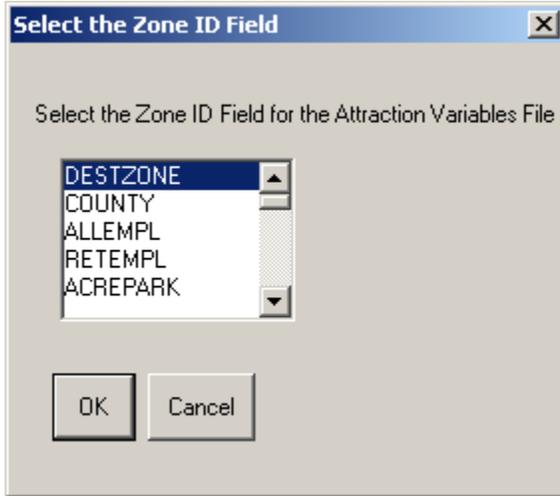
### Step 8-7. Zone Designation

Select the field that designates **traffic zones** (the zone being used for this run) in the dataview associated with the map layer for the region. Click **OK**.



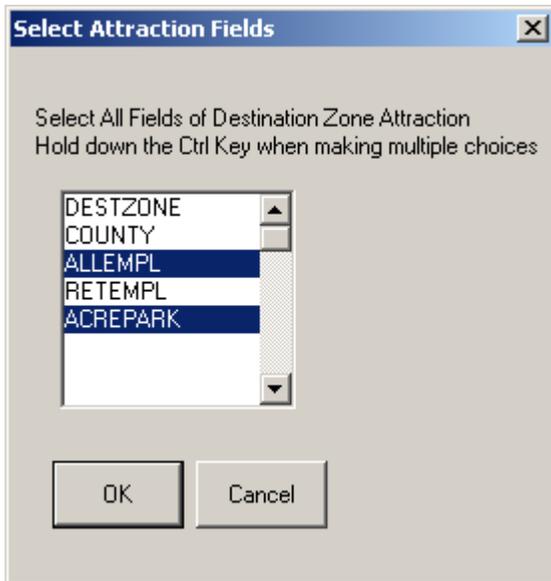
### Step 8-8. Zone ID Field

Select the field that designates the same **traffic zone** referred to in step 8-6 above in the Attraction Variables File. Click **OK**.



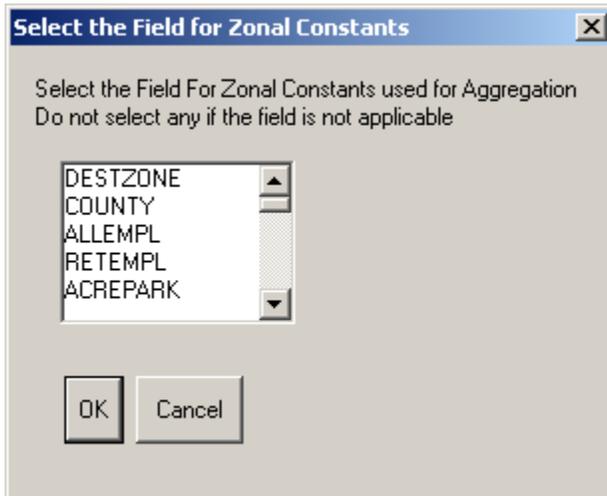
### Step 8-9. Select Attraction Fields

Select all fields that need to be summed to obtain the total attraction of each destination zone for the trip purpose under consideration from the scroll list. Click **OK**.



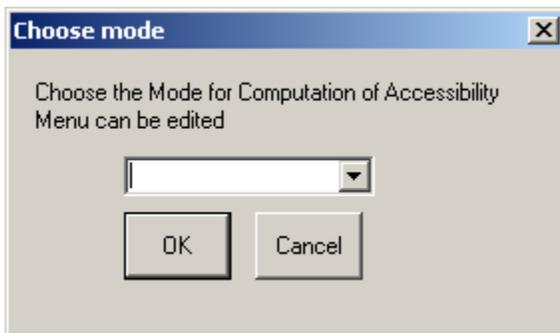
### Step 8-10. Zonal Constants

Select the field that designates the constant multiplier for each destination zone for the region. These constants are only used for aggregation runs. For further explanation of zonal constants please refer to Chapter 2.



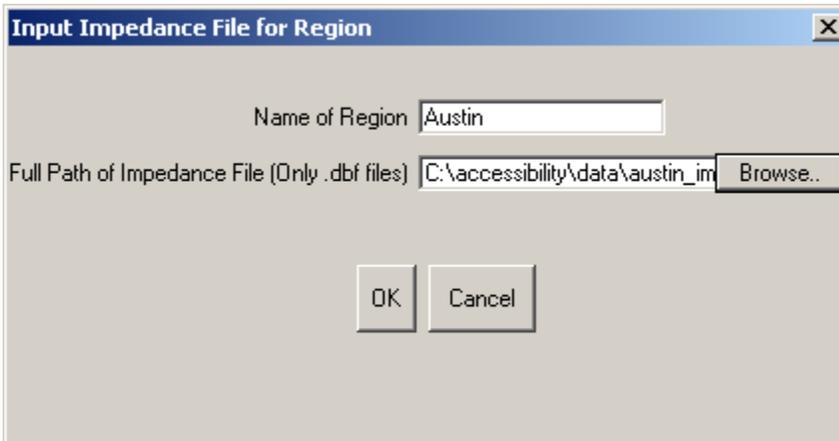
### Step 8-11. Choose Mode

Select or **enter** a mode name from the **editable** drop-down menu.



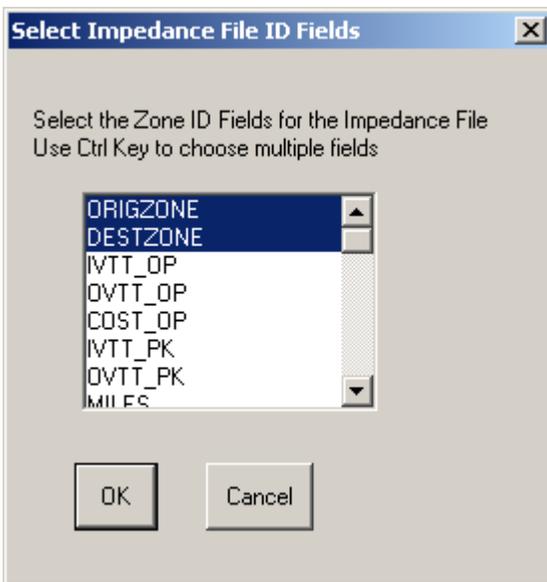
### Step 8-12. Input Impedance File

Enter the full path of the impedance variables file for the region being analyzed. Click on **Browse**, navigate to the file and click **OK**.



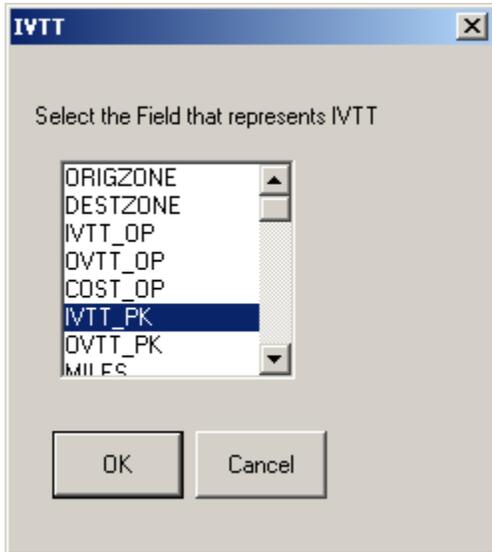
### Step 8-13. Select Impedance File ID Fields

Select the fields that designate the origin traffic zone and the destination traffic zone in the Impedance Variables file from the scroll list. Click **OK**.



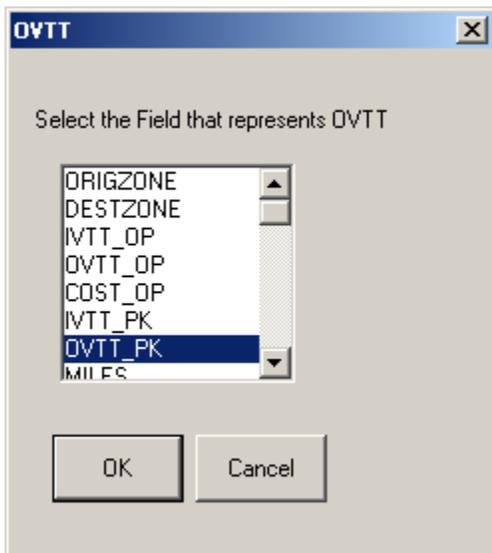
### Step 8-14. IVTT

Select the field in the impedance variables file that designates **IVTT** for the mode and time of day used in this run from the scroll list. Click **OK**.



### Step 8-15. OVTT

Select the field in the impedance variables file that designates **OVTT** for the mode and time of day used in this run from the scroll list. Click **OK**.



### Step 8-16. Cost

Select the field in the impedance variables file that designates **Cost** for the mode and time of day used in this run from the scroll list. Click **OK**.



Depending on the size of the data files being processed the program can take up to 45 minutes to produce an output.

**Note:** TransCAD may appear as *Not responding* in the Task Menu. Please do not end the TransCAD session in this case. A result will be produced after the program is finished running.

## 9. Mode and Time of Day Aggregation

Aggregation across modes and times of day also follows the multinomial logit model with the aggregation weighted by people's choice of mode to use and time of day to travel. This chapter provides instructions on this run.

**For Built-In Data** – Please refer to Chapter 3.

**For User-Provided Data**

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### Step 9-1. Choose Level of Aggregation

After selecting a region, choose **Mode & Time of Day** from the drop-down menu. Click **OK**.

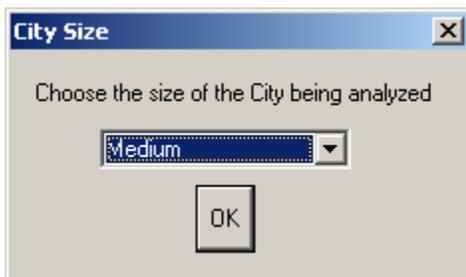
### Step 9-2. Choose Purpose

Select a **trip purpose** for the run from the drop-down menu. Click **OK**.



### Step 9-3. City Size

Select the size of the city being considered from the drop-down menu. Click **OK**.



### Step 9-4. Recommended Parameters

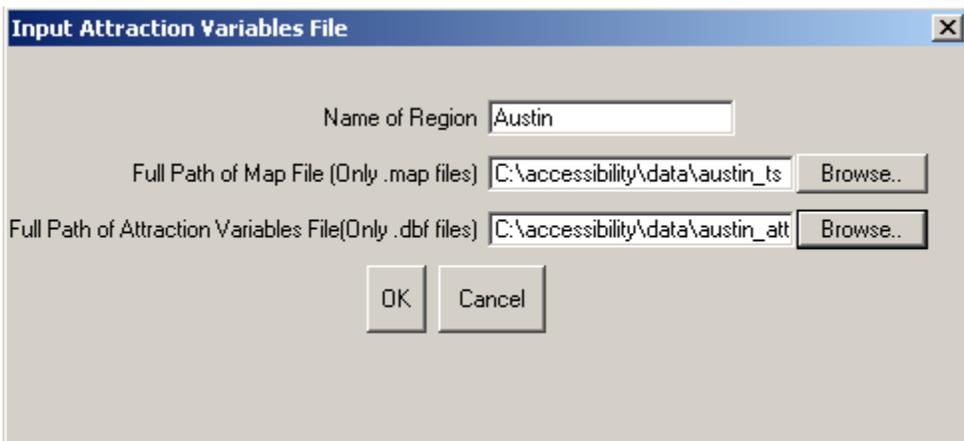
Based on the city size chosen, the software will display the parameters that it recommends for the Accessibility run. A detailed explanation of this dialog box is in step 3-4. Please refer to that and make any necessary changes before clicking **OK**.

### Step 9-5. Input Attraction Variables File

In the dialog box, enter the **name of the region**. Enter the **full directory location path** of the TransCAD map file in the **Full Path of Map file** text box. Click on **Browse** to navigate to the file and choose **OK**.

**Note:** Ensure that all the associated files to the .map file reside in the same directory as the file itself.

Enter the **full directory location path** of the dBASE IV file that holds the attraction data



for each traffic zone for the region under analysis in the **Full path of attraction variables file** text box. Click on **Browse** to navigate to the file and choose **OK**.

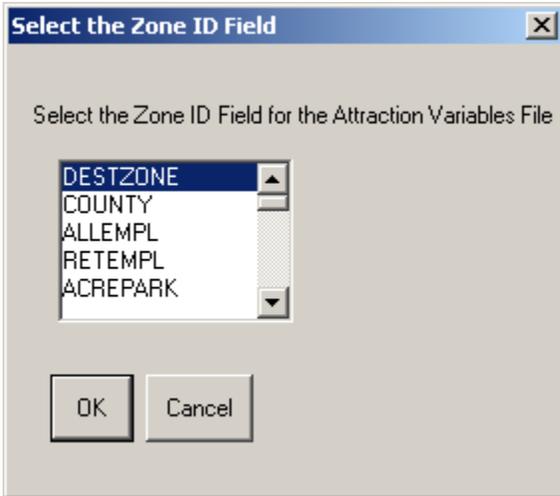
### Step 9-6. Zone Designation

Select the field that designates **traffic zones** (the zone being used for this run) in the dataview associated with the map layer for the region. Click **OK**.



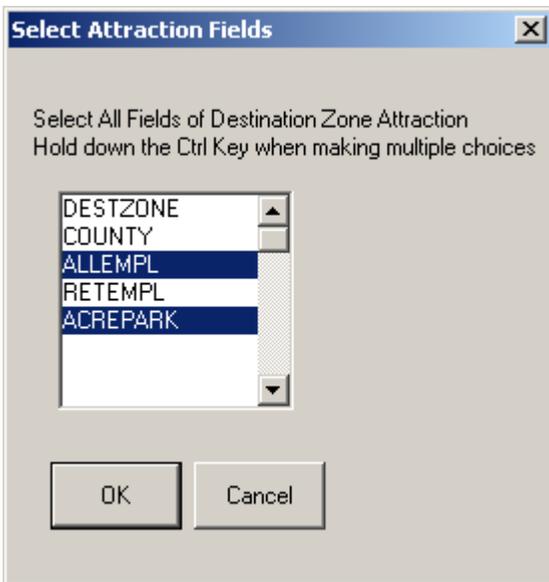
### Step 9-7. Zone ID Field

Select the field that designates the same **traffic zone** referred to in step 9-5 above in the Attraction Variables File. Click **OK**.



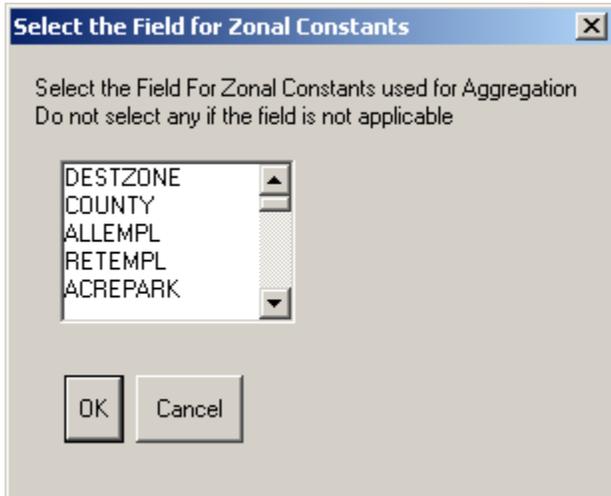
### Step 9-8. Select Attraction Fields

Select all fields that need to be summed to obtain the total attraction of each destination zone for the trip purpose under consideration from the scroll list. Click **OK**.



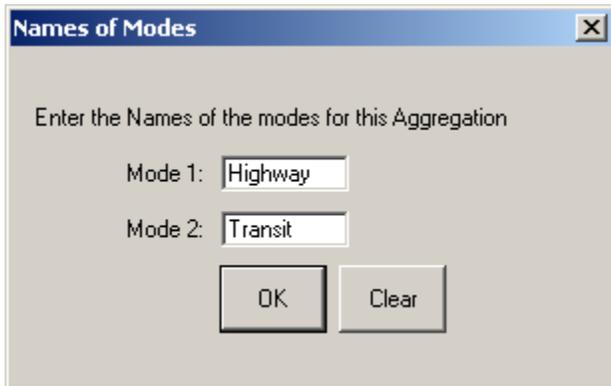
### Step 9-9. Zonal Constants

Select the field that designates the constant multiplier for each destination zone for the region. These constants are only used for aggregation runs. For further explanation of zonal constants please refer to Chapter 2.



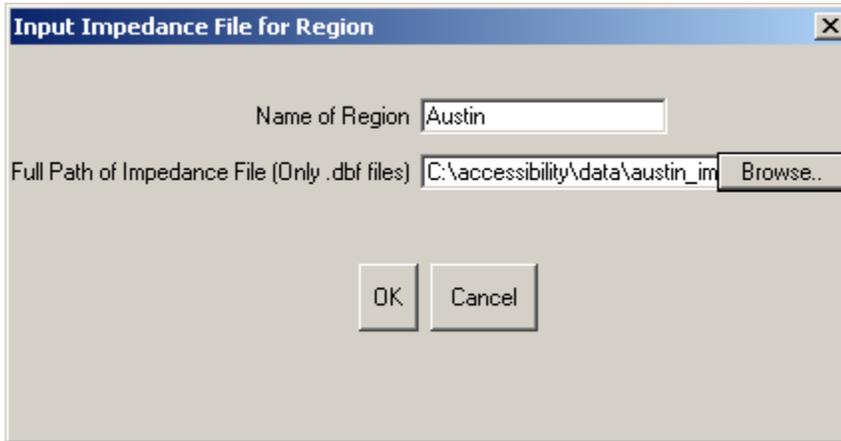
### Step 9-10. Mode Names

Enter the names of the two modes being analyzed in this aggregate run. Click **OK**.



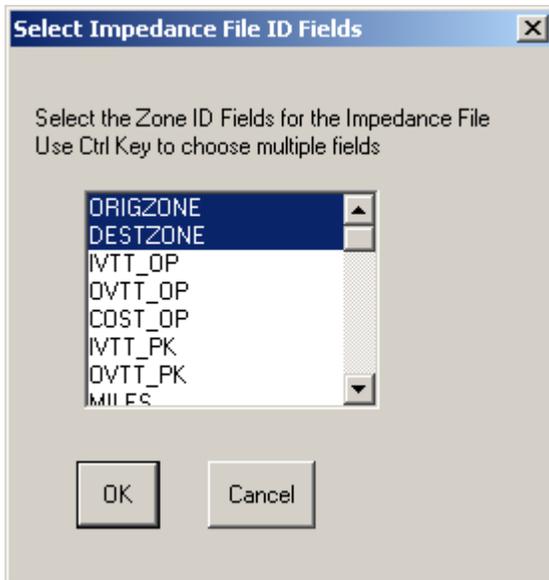
### Step 9-11. Input Impedance File

Enter the full path of the impedance variables file for the region being analyzed. Click on **Browse**, navigate to the file and click **OK**.



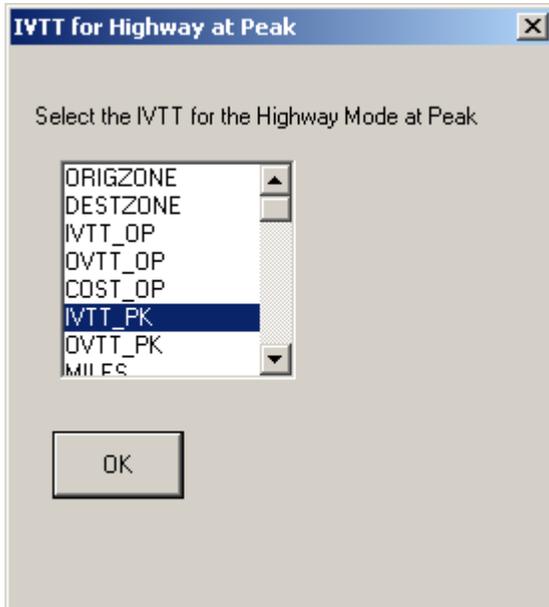
### Step 9-12. Select Impedance File ID Fields

Select the fields that designate the origin traffic zone and the destination traffic zone in the Impedance Variables file from the scroll list. Click **OK**.



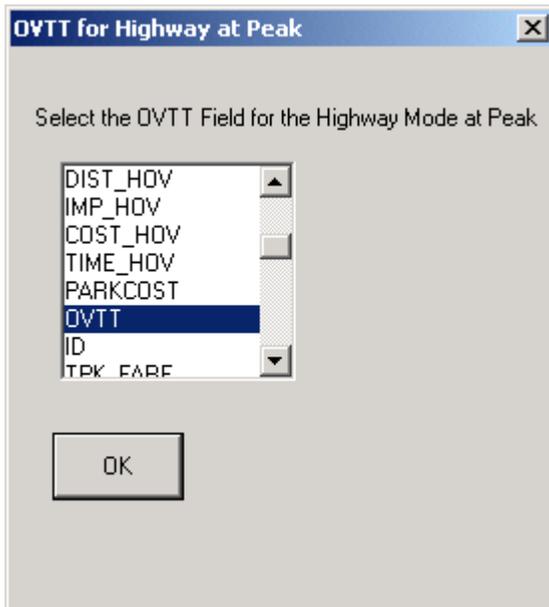
### Step 9-13. IVTT

Select the field that represents **IVTT** for the **mode shown in the dialog box** during **Peak** time in the impedance variables file from the scroll list. Click **OK**.



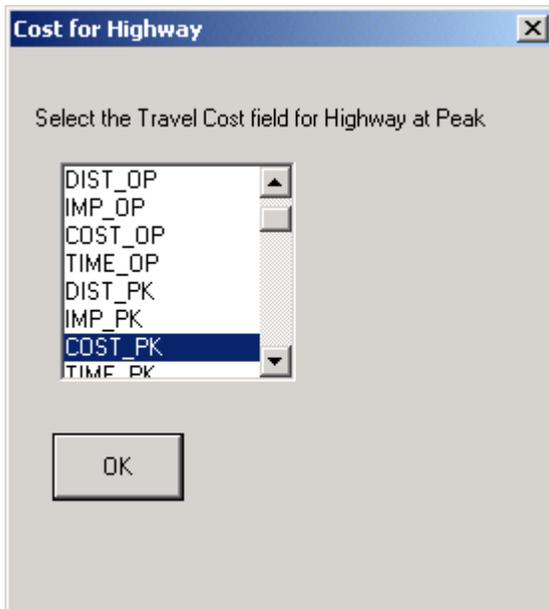
### Step 9-14. OVTT

Select the field that represents **OVTT** for the **mode shown in the dialog box** during **Peak** time in the impedance variables file from the scroll list. Click **OK**.



### Step 9-15. Cost

Select the field that represents **Cost** for the **mode shown in the dialog box** during **Peak** time in the impedance variables file from the scroll list. Click **OK**.



### Steps 9-16 – 9-18. IVTT, OVTT, and Cost for Mode 2 at Time 1

Repeat steps 9-13 – 9-15 for Mode 2.

### Steps 9-19 – 9-21. IVTT, OVTT, and Cost for Mode 1 at Time 2

Repeat steps 9-13 – 9-15 for Mode 1 at Time 2.

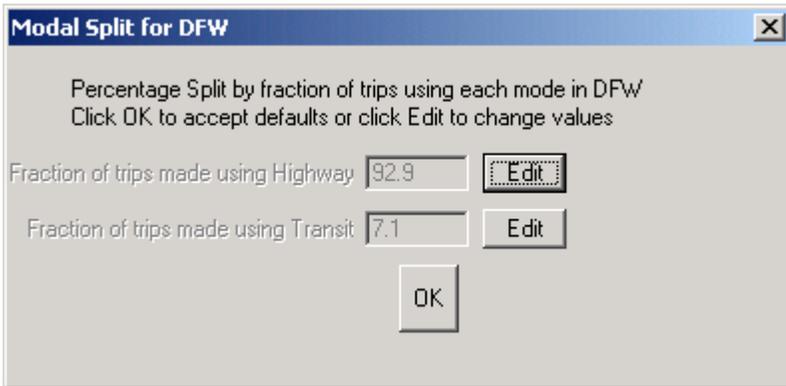
### Steps 9-22 – 9-24. IVTT, OVTT, and Cost for Mode 2 at Time 2

Repeat steps 9-13 – 9-15 for Mode 2 at Time 2.

### Step 9-25. Modal Split

To compute aggregate accessibility across modes, the software requires the percentage of trips made using each mode in the region. The default values provided are based on current data for Austin (an example of a medium size city in Texas) and Dallas/Fort Worth (an example of a large city in Texas). Click on **Edit** to alter values if these are

available for the city under consideration. Click **OK**.

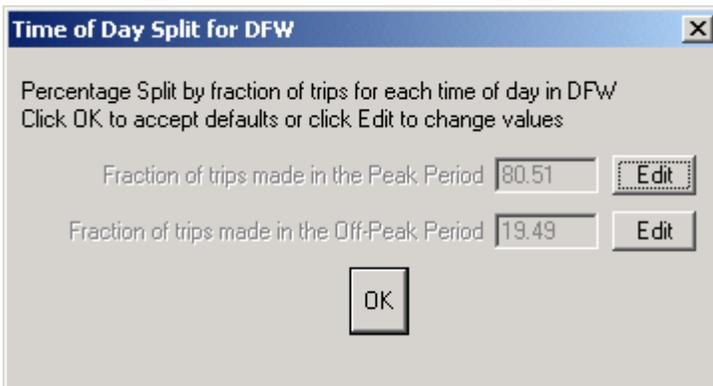


The dialog box titled "Modal Split for DFW" contains the following text: "Percentage Split by fraction of trips using each mode in DFW" and "Click OK to accept defaults or click Edit to change values". It features two input fields: "Fraction of trips made using Highway" with a value of 92.9 and an "Edit" button, and "Fraction of trips made using Transit" with a value of 7.1 and an "Edit" button. A central "OK" button is also present.

Mode	Fraction of trips	Action
Highway	92.9	Edit
Transit	7.1	Edit

### Step 9-26. Time of Day Split

Similarly, enter the percentage split of trips by time of day. Data input in this and the previous box are used to aggregate across both modes and times of day.



The dialog box titled "Time of Day Split for DFW" contains the following text: "Percentage Split by fraction of trips for each time of day in DFW" and "Click OK to accept defaults or click Edit to change values". It features two input fields: "Fraction of trips made in the Peak Period" with a value of 80.51 and an "Edit" button, and "Fraction of trips made in the Off-Peak Period" with a value of 19.49 and an "Edit" button. A central "OK" button is also present.

Time of Day	Fraction of trips	Action
Peak Period	80.51	Edit
Off-Peak Period	19.49	Edit

Processing will begin and will take up to 45 minutes based on the size of files being processed. A map and table will be produced as output.

## 10. Mode and Trip Purpose Aggregation

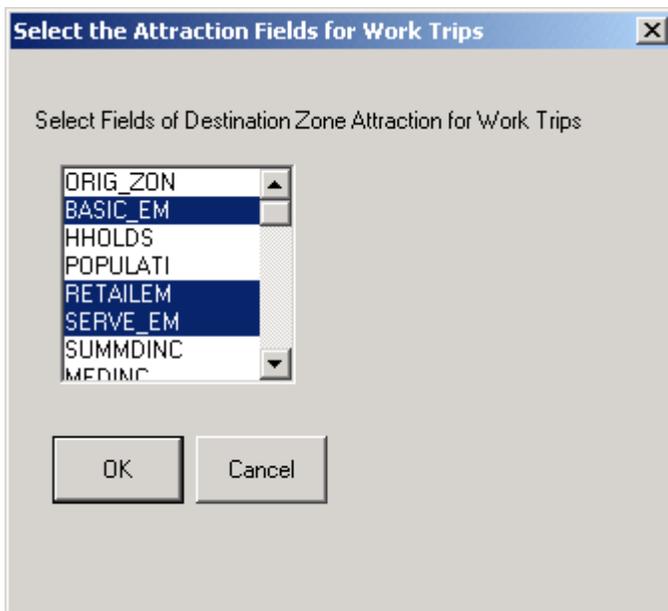
Most of the screens that have appeared in previous runs will appear here again. Please follow instructions from previous chapters for these screens. Only new screens specific to this run are explained in this chapter.

**For Built-In Data** – Please refer to Chapter 3.

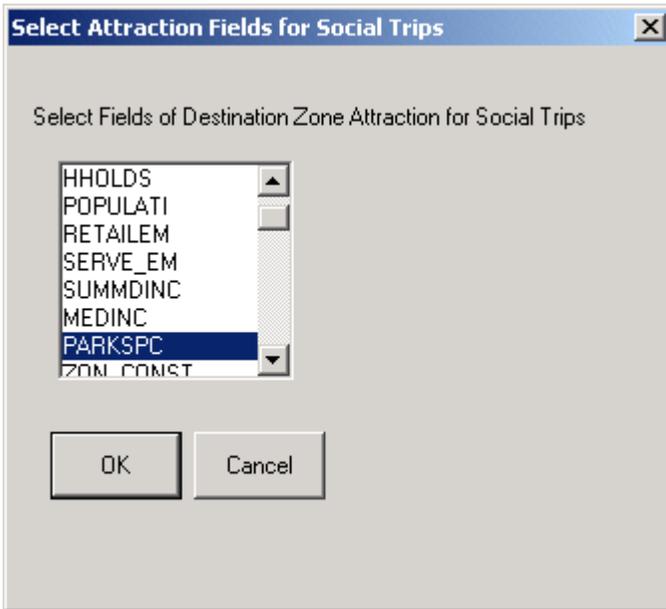
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### For User-Provided Data

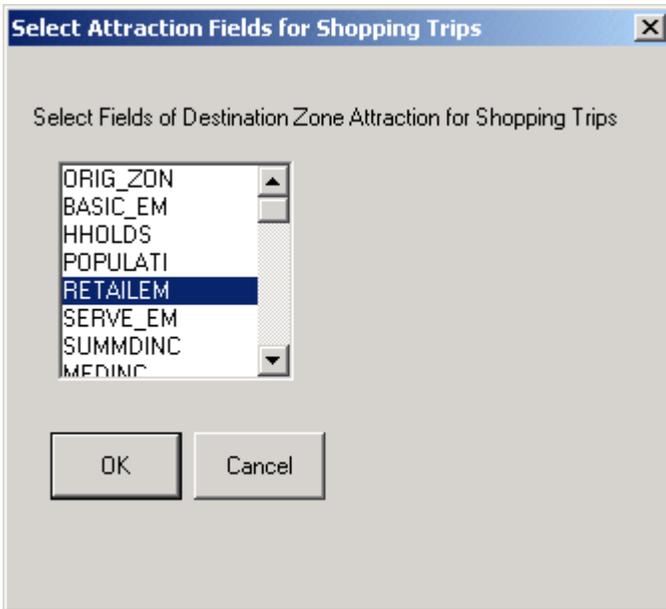
- After defining the path of the attraction variables and its zone field, the **Select Attraction Fields for Work Trips** box will appear. Use the control key to choose all the fields from the scroll list that are used to compute destination zone attraction for this purpose.



- The **Select Attraction fields for Social-Recreational Trips** dialog box will appear next. Use the control key and mouse to select all the fields from the scroll list that are to be summed to obtain destination zone attraction.



- The **Select Attraction fields for Shopping Trips** box will appear next. Use the control key and mouse to select all the fields that need to be summed to obtain destination zone attraction.



- The screens that follow have all been explained in detail earlier. The run can take up to 45 minutes depending on the size of the files to be processed. A TransCAD map and dbf database table will be produced as a result.

## 11. Mode and Zone Aggregation

**For Built-In Data Sets** – refer to Chapter 3.

### **For User-Provided Data Sets**

- Choose **Mode & Zone** in the Choose Level of Aggregation drop-down menu. Click **OK**.
- Then follow steps 6-2 through 6-20 of **Chapter 6: Mode Only Aggregation** for this run.
- The output map will show a single value which is the aggregate accessibility across all zones and modes for the region. The run might take up to 45 minutes to produce the output. Do not shut down TransCAD if it shows up as *Not responding* in the task menu.



## 12. Trip Purpose & Time of Day Aggregation

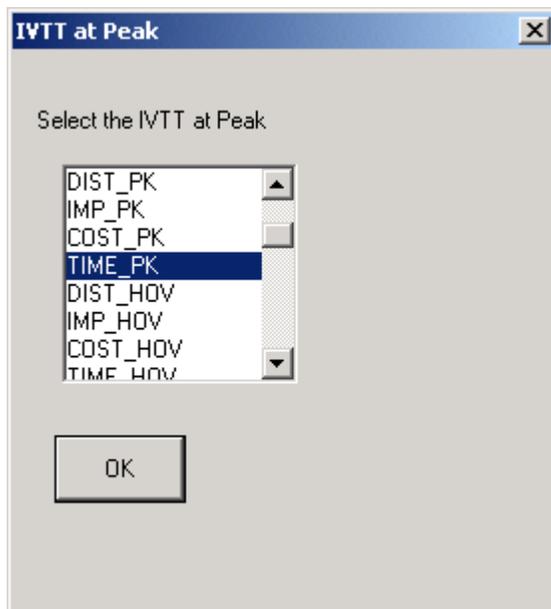
**For Built-In Data Sets** – refer to Chapter 3.

### For User-Provided Data Sets

- Follow steps 7-1 through 7-14, skipping step 7-4, in **Chapter 7: Trip Purpose Only Aggregation**.

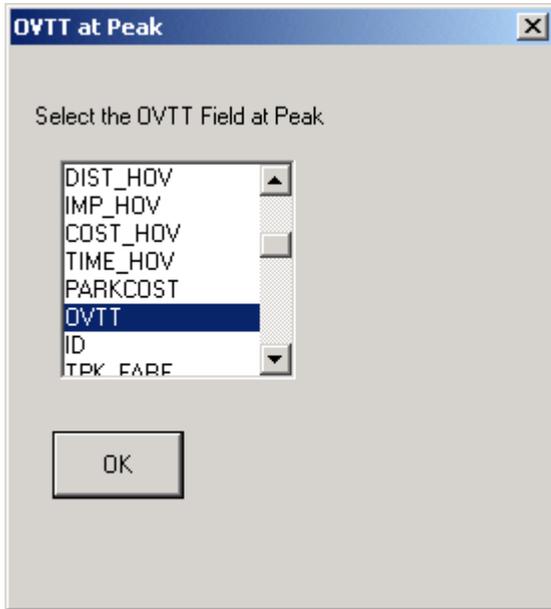
### Step 12-15. IVTT

For the mode you chose for this run, select the field that represents **IVTT at Peak** from the impedance variables file for the region under analysis. Click **OK**.



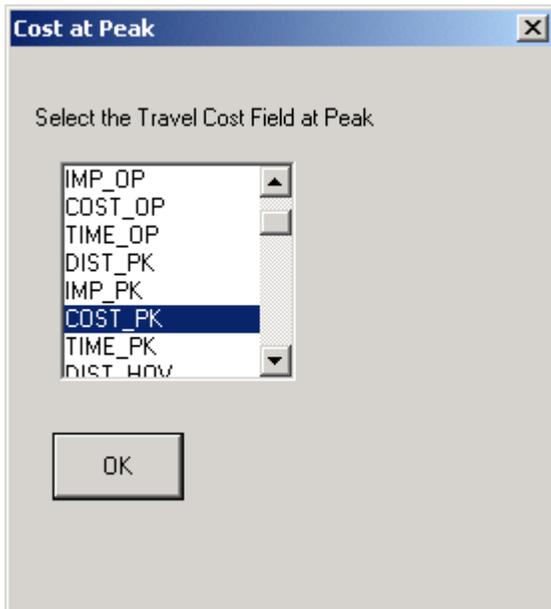
### Step 12-16. OVTT

For the mode you chose for this run, select the field that represents **OVTT at Peak** from the impedance variables file for the region under analysis. Click **OK**.



### Step 12-17. Cost

For the mode you chose for this run, select the field that represents **Cost at Peak** from the impedance variables file for the region under analysis. Click **OK**.



## Steps 12-18 – 12-20. IVTT, OVTT, and Cost for Off-Peak

Repeat steps 12-15 – 12-17 for Off-Peak.

### Step 12-21. Time of Day Split

To perform the aggregation using the multinomial logit model, it is essential to know the percentage split of trips between each time period for the region under consideration.

Default values for these based on current data for Austin (medium size Texas city) and Dallas/Fort Worth (large size Texas city) are provided in the Time of Day Split dialog box. Click on **Edit** to change these values if you have this data, else accept the defaults.

Click **OK** to accept.

Time of Day Split for DFW

Percentage Split by fraction of trips for each time of day in DFW  
Click OK to accept defaults or click Edit to change values

Fraction of trips made in the Peak Period 80.51 Edit

Fraction of trips made in the Off-Peak Period 19.49 Edit

OK

### Step 12-22. Trip Purpose Split

The Trip Purpose Split dialog box is similar to the one above, with respect to trip purposes. Click **Edit** to change default values. Click **OK** to accept.

Trip Purpose Split for DFW

Percentage Split by fraction of trips for each trip purpose in DFW  
Click OK to accept defaults or click Edit to change values

Fraction of trips made for the purpose of Work 26.81 Edit

Fraction of trips made for Social-Recreational Purposes 33.75 Edit

Fraction of trips made for the purpose of Shopping 39.43 Edit

OK

The program can take up to 45 minutes to produce an output.



## 13. Trip Purpose and Zone Aggregation

**For Built-In Data Sets** – refer to Chapter 3.

### **For User-Provided Data Sets**

- Choose **Trip Purpose & Zone** from the Choose Level of Aggregation drop-down menu. Click **OK**.
- Then follow steps 7-22 through 7-18 in **Chapter 7: Trip Purpose Only Aggregation**.
- The run may take up to 45 minutes to produce an output.



## 14. Time of Day and Zone Aggregation

**For Built-In Data** – refer to Chapter 3.

### **For User-Provided Data**

- Choose **Time of Day & Zone** from the Choose Level of Aggregation drop-down menu.  
Click **OK**.
- Then follow steps 8-2 through 8-32 in **Chapter 8: Time of Day Only Aggregation Run**.
- The run can take up to 45 minutes to produce an output depending on file sizes.



## 15. Mode, Trip Purpose and Time of Day Aggregation

**For Built-In Data** – refer to Chapter 3.

### For User-Provided Data

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#### Step 15-1. Choose Level of Aggregation

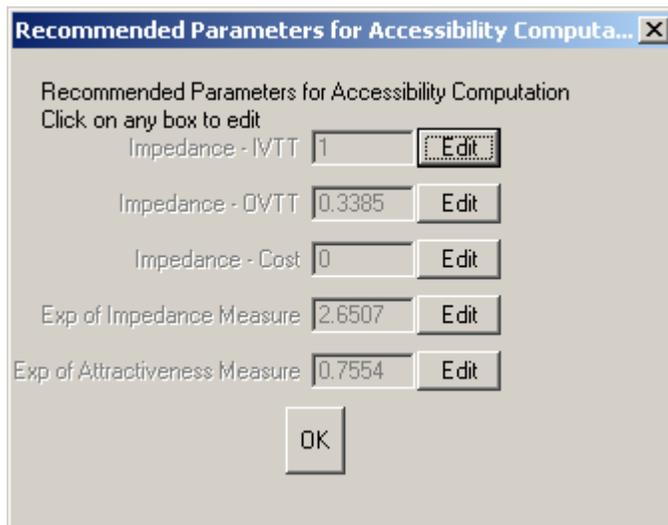
Choose **Mode, Trip Purpose and Time of Day** from the drop-down menu. Click **OK**.

#### Step 15-2. City Size

Choose the size of the city being analyzed from the drop-down menu. Click **OK**.

#### Step 15-3. Recommended Parameters

Accept or Edit and accept the parameters presented. This box is explained in step 3-4.

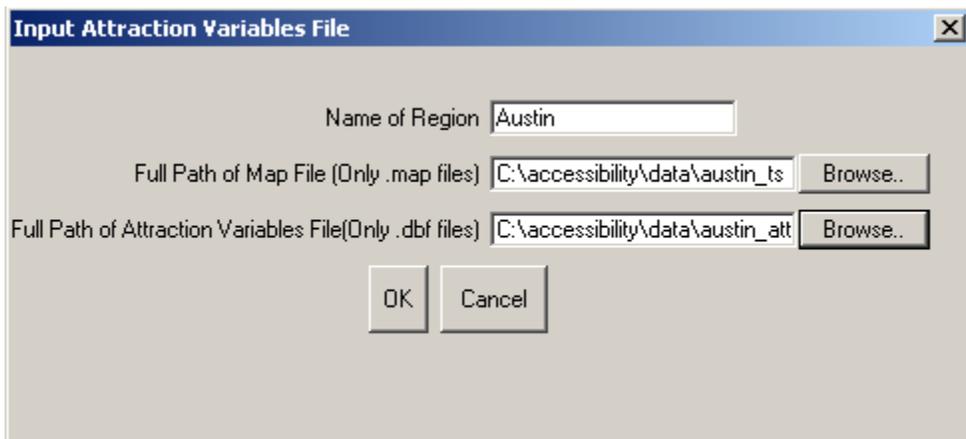


#### Step 15-4. Input Attraction Variables File

In the dialog box, enter the name of the region. Enter the full directory location path of the TransCAD map file in the **Full Path of Map file** text box. Click on **Browse** to navigate to the file and choose **OK**.

**Note:** Ensure that all the associated files to the .map file reside in the same directory as the file itself.

Enter the full directory location path of the dBASE IV file that holds the attraction data for each traffic zone for the region under analysis in the **Full path of attraction variables file** text box. Click on **Browse** to navigate to the file and choose **OK**.



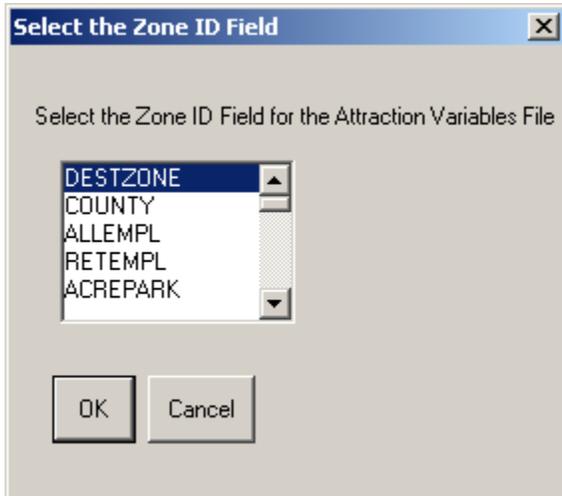
#### Step 15-5. Zone Designation

Select the field that designates traffic zones (the zone being used for this run) in the dataview associated with the map layer for the region. Click **OK**.



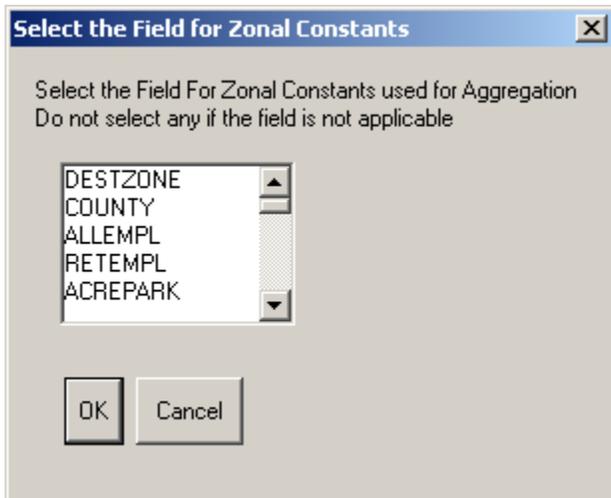
### Step 15-6. Zone ID Field

Select the field that designates the same traffic zone referred to in step 15-4 above in the Attraction Variables File. Click **OK**.



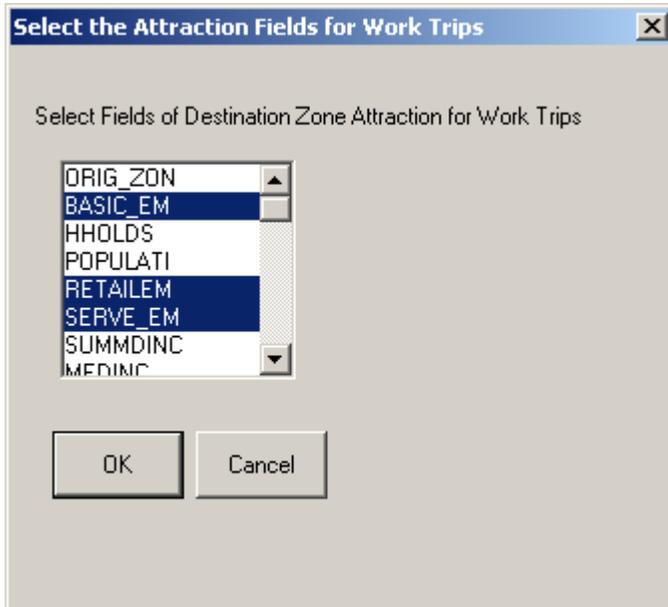
### Step 15-7. Zonal Constants

Select the field that designates the constant multiplier for each destination zone for the region. These constants are only used for aggregation runs. For further explanation of zonal constants please refer to Chapter 2.



### Step 15-8. Select Attraction Fields for Work Trips

Select all the fields that need to be summed to obtain destination zone attraction for Work trips. Use the Control key and mouse to make multiples choices. Click **OK** when done.



### Step 15-9 – 15-10. Select Attraction Fields for Social-Recreation and Shopping Trips

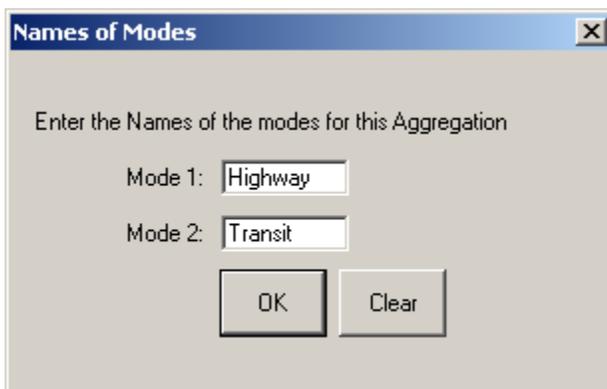
Repeat step 15-8 for Social Recreation and Shopping Trips.

Select all the fields that need to be summed to obtain destination zone attraction for Social-

### Step 15-11. Mode Names

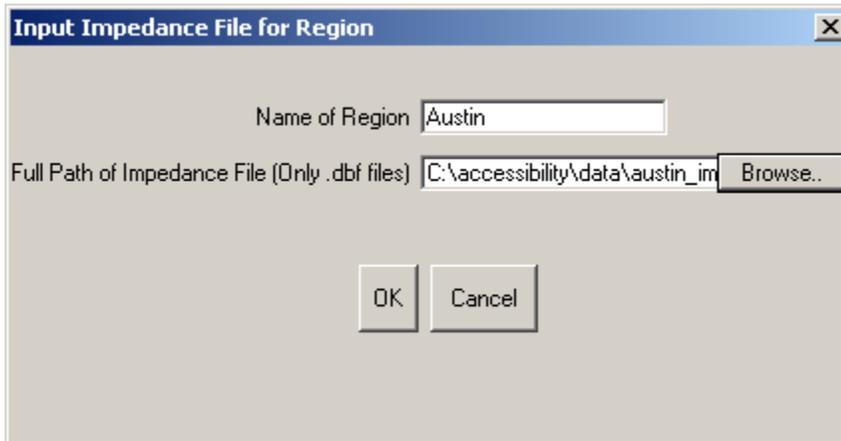
Enter the names of the two modes for which data is being input for this Aggregation run.

In the example shown below, these are **Highway** and **Transit**. Click **OK** when done.



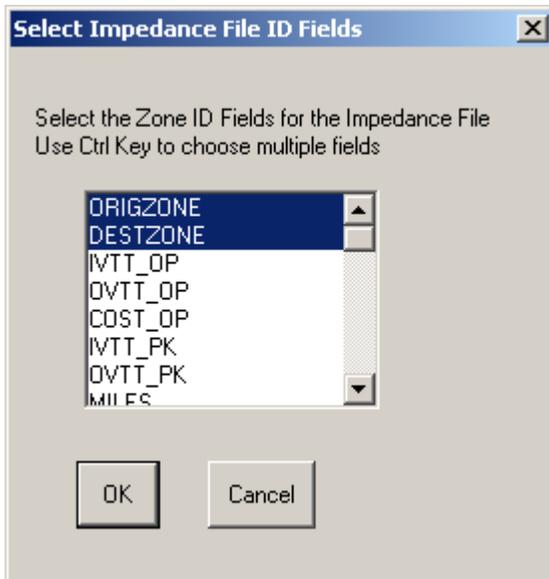
### Step 15-12. Input Impedance File

Enter the full path of the impedance variables file for the region being analyzed. Click on **Browse**, navigate to the file and click **OK**.



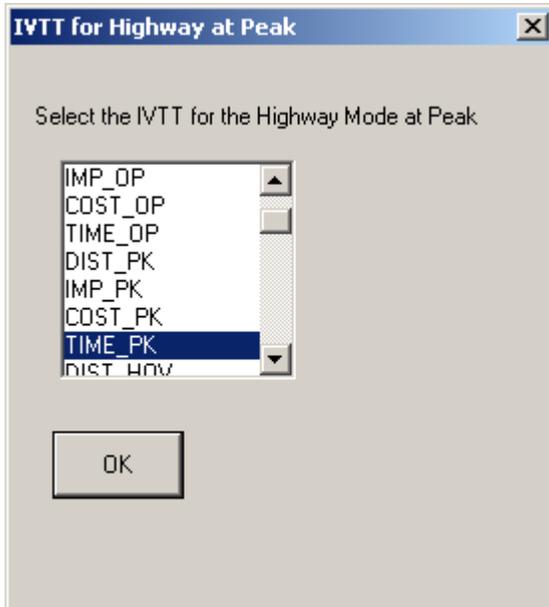
### Step 15-13. Select Impedance File ID Fields

Select the fields that designate the origin traffic zone and the destination traffic zone in the Impedance Variables file from the scroll list. Click **OK**.



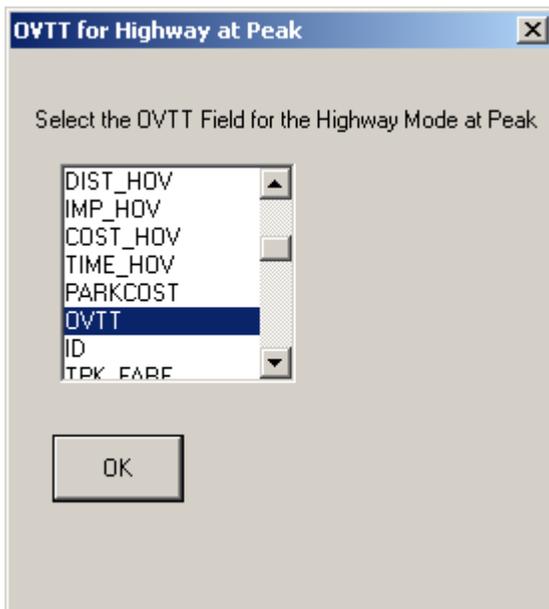
### Step 15-14. IVTT

Select the field that represents IVTT during the peak time of day for the mode shown in the dialog box prompt from the impedance variables file. Click **OK**.



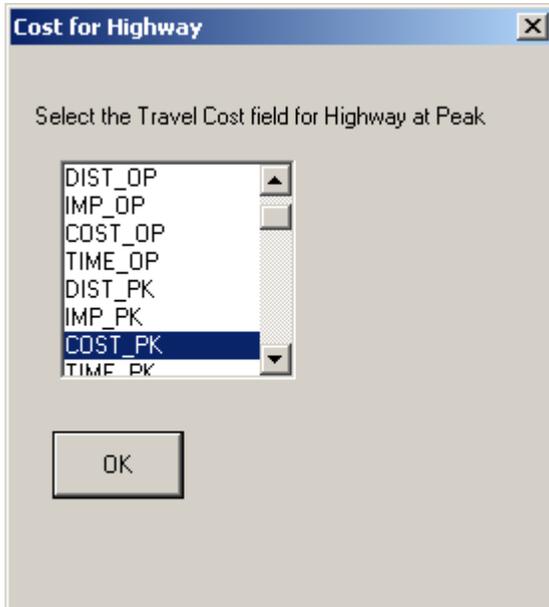
### Step 15-15. OVTT

Select the field that represents OVTT during the peak time of day for the mode mentioned in the dialog box prompt from the impedance variables file. Click **OK**.



### Step 15-16. Cost

Select the field that represents cost during the peak time of day for the mode selected in the dialog box prompt from the impedance variables file. Click **OK**.



### Steps 15-17 – 15-19. IVTT, OVTT, and Cost for Mode 2 at Time of Day 1

Repeat steps 17-14 – 17-16 for the second mode at Time of Day 1.

### Steps 15-20 – 15-22. IVTT, OVTT, and Cost for Mode 1 at Time of Day 2.

Repeat steps 17-14 – 17-16 for the first mode at Time of Day 2.

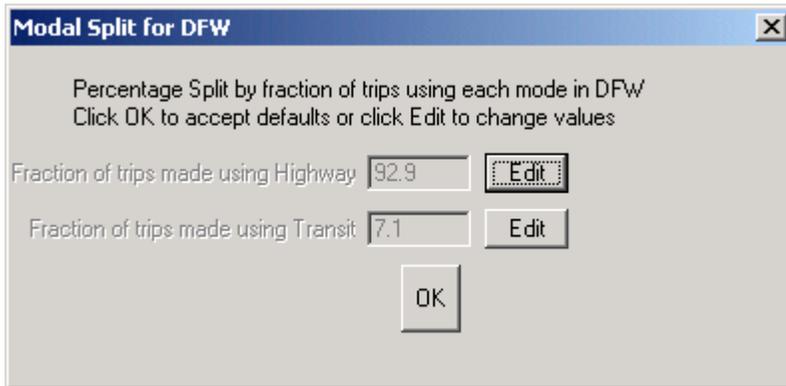
### Step 15-23 – 15-25. IVTT, OVTT, and Cost for the second mode at Time of Day 2

Repeat steps 17-14 – 17-16 for the second mode at Time of Day 2.

### Step 15-26. Modal Split

To compute aggregate accessibility across modes, the software requires the percentage of trips made using each mode in the region. The default values provided are based on current data for Austin (an example of a medium size city in Texas) and Dallas/Fort Worth (an example of a large city in Texas). Click on **Edit** to alter values if these are

available for the city under consideration. Click **OK**.



The dialog box titled "Modal Split for DFW" contains the following text and controls:

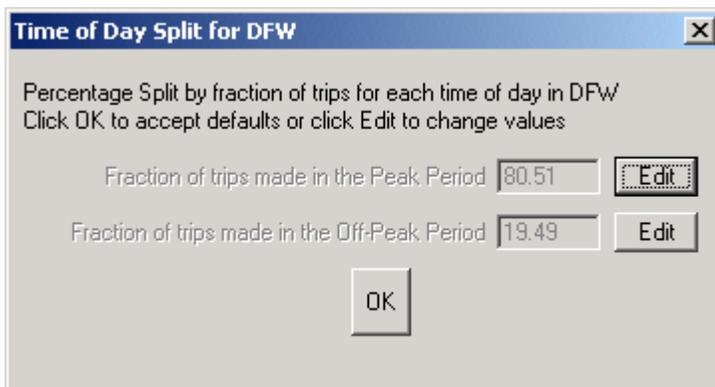
Percentage Split by fraction of trips using each mode in DFW  
Click OK to accept defaults or click Edit to change values

Fraction of trips made using Highway

Fraction of trips made using Transit

### Step 15-27. Time of Day Split

To perform the aggregation using the multinomial logit model, it is essential to know the percentage split of trips between each time period for the region under consideration. Default values for these based on current data for Austin (medium size Texas city) and Dallas/Fort Worth (large size Texas city) are provided in the Time of Day Split dialog box. Click on **Edit** to change these values if you have this data, else accept the defaults. Click **OK** to accept.



The dialog box titled "Time of Day Split for DFW" contains the following text and controls:

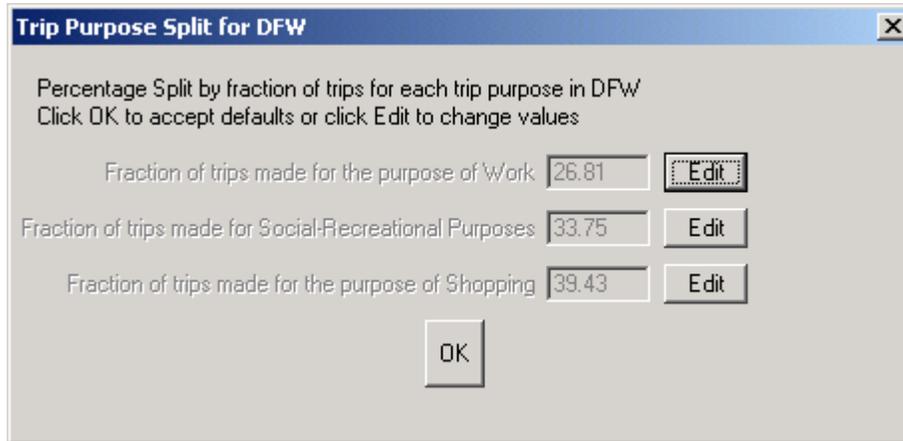
Percentage Split by fraction of trips for each time of day in DFW  
Click OK to accept defaults or click Edit to change values

Fraction of trips made in the Peak Period

Fraction of trips made in the Off-Peak Period

### Step 15-28. Trip Purpose Split

The Trip Purpose Split dialog box is similar to the one above, with respect to trip purposes. Click **Edit** to change default values. Click **OK** to accept.



**Note:** The program can take up to 45 minutes to produce an output depending on the file sizes input.



## 16. Mode, Trip Purpose and Zone Aggregation

**For Built-In Data** – refer to Chapter 3.

### **For User-Provided Data**

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- **Choose Level of Aggregation**

Choose **Mode, Trip Purpose and Zone** in the drop-down menu. Click **OK**.

- Follow the same steps as outlined in Chapter 11 for mode and zone aggregation. Follow the steps in Chapter 6 regarding trip purpose aggregation. All the dialog boxes are explained in detail in earlier chapters.

**Note:** The run can take up to 45 minutes depending on the input file sizes.



## 17. Trip Purpose, Time of Day and Zone Aggregation

**For Built-In Data** – refer to Chapter 3.

### **For User-Provided Data**

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#### **Step 17-1. Choose Level of Aggregation**

Choose **Trip Purpose, Time of Day and Zone** from the drop-down menu. Click **OK**.

#### **Steps 17-2 – 17-14.**

Follow steps 6-1 through 6-14, skipping step 4, in Chapter 6: Trip Purpose Only Aggregation.

#### **Steps 17-15 – 17-22.**

Follow steps 15 through 22 from Chapter 12: Trip Purpose and Time of Day Aggregation.

**Note:** The run can take up to 45 minutes to produce a result.



## 18. Mode, Time of Day and Zone Aggregation

**For Built-In Data** – refer to Chapter 3.

### **For User-Provided Data**

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#### **Step 18-1. Choose Level of Aggregation**

Choose **Mode, Time of Day & Zone** from the drop-down menu. Click **OK**.

#### **Steps 18-2 – 18-26.**

Follow steps 9-2 through 9-26 in Chapter 9: Mode and Time of Day Aggregation.

**Note:** The run may take up to 45 minutes to produce a result.



## 19. Aggregation Across All Levels

**For Built-In Data** – refer to Chapter 3.

### **For User-Provided Data**

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#### **Step 19-1. Choose Level of Aggregation**

Choose **All** from the drop-down menu. Click **OK**.

#### **Steps 19-2 – 19-28.**

Follow steps 2 through 28 in Chapter 15: Mode, Trip Purpose and Time of Day Aggregation.

**Note:** The run may take up to 45 minutes to produce a result depending on the size of input files.



## 20. Understanding and Manipulating the Output

Each of the sixteen runs of the program will produce one TransCAD map and one dBASE IV file as output. The map will be color-coded and will show the geographic distribution of accessibility for the region. This can be treated as any other TransCAD layer and all regular TransCAD operations can be performed on it. The dBASE file can be saved or exported into other programs for further analysis and manipulation.

### The dBASE File

---

A simple database table showing the accessibility of each traffic zone is produced by the program.

#### Structure and Location of the File

For a run which does not include any type of zonal aggregation, the dBASE file will have two fields:

- **TAPZONE** – this field represents each traffic zone of the region as specified by the map, attraction variables and impedance variables files provided as inputs;
- **ACC** – this field represents the value of the Accessibility of the corresponding traffic zone as computed by the software.

For runs that include any zonal aggregation, the table will have an additional field:

- **AGGZONE** – this field shows the higher zonal unit (to which the aggregation has been run like TAD zones or counties) to which the corresponding traffic zone (represented by the field TAPZONE) belongs. This field is relevant only for Dallas/Fort Worth when aggregating over TAD zones or counties. For all other runs, AGGZONE = 1 for every TAPZONE value.

**Location** - The path of this dBASE file is **c:\accessibility\acc\_vals\_table.dbf**. So please ensure that the directory **c:\accessibility** is created when the software is installed. Otherwise an error will occur when writing the output.

#### Saving and Exporting the File

In the main TransCAD window, go to **File - Save As** to save the output under a new file name and location. TransCAD will allow you to save the file in many different formats which can then be manipulated in other applications. You have to save the file under a new name if you wish to compare this run with others for the same region using the Map Compare Add-In.

**Note:** Just doing **File - Save** will cause the file to be over-written the next time the program is run. Ensure that you are saving the file under a new name and folder.

## The TransCAD Map

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A TransCAD map showing a color-coded distribution of accessibility values for the region is also produced at the end of each run.

### Characteristics of the Map

The color-coded output is produced by joining the original TransCAD map file of the region with the dBASE file mentioned above. The theme is created on the field *ACC*. The default theme is an Equal Number of Features method divided into 5 classes. These are meant to signify:

1. Relatively Very Low Accessibility,
2. Relatively Low Accessibility,
3. Relatively Average Accessibility,
4. Relatively High Accessibility, and
5. Relatively Very High Accessibility.

In addition, there will be a sixth class named Others which houses zero and outlying values. You can alter these settings to anything you desire by clicking on the **Color Theme** icon in the main TransCAD window.

All features and operations that can be performed on a TransCAD map can be done on this output map. Some examples are:

- change the colors under the *Map* menu options; and
- overlay other themes such as detailed streets of the region.

### Saving and Exporting the Map

In the main TransCAD window go to **File - Save As** to save the map under a new name and location on your hard drive. TransCAD will provide you many format options to save the file such as bitmaps, jpegs and so on. Save the file as a .map file if you wish to perform further TransCAD operations on it. This is the most useful format to save. Save as image files if you need the maps for aesthetic and static use.

**Note:** Just doing **File - Save** will cause the image to be lost when the next run of the software is made since the current theme will then be erased.



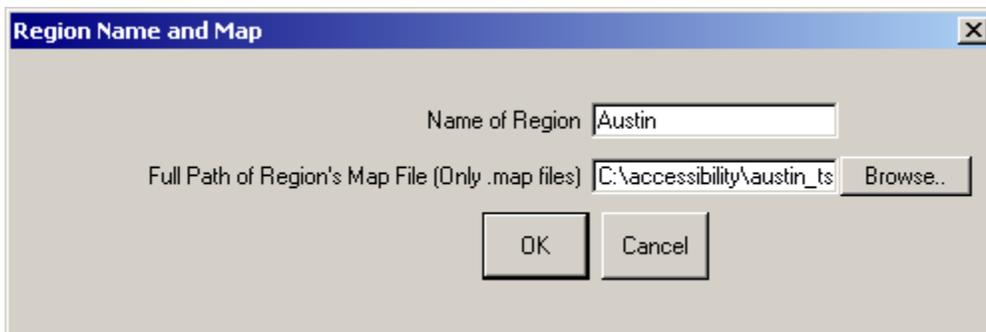
## 21. Using the Map Compare Add-In

Individual accessibility runs, while useful, are not as versatile as comparisons between different runs. The mathematical formulations used for all levels of aggregation and disaggregation allow for direct comparison of values between any two different runs for the same region. A comparison between runs for two different regions cannot be direct however. The software comes with an add-in that compares two different runs for the same region and plots it on a color-coded map. To run Map Compare you need to have saved the dBASE output files from the runs you wish to compare under new names. The original map file can be used for plotting the color theme.

### Running Map Compare

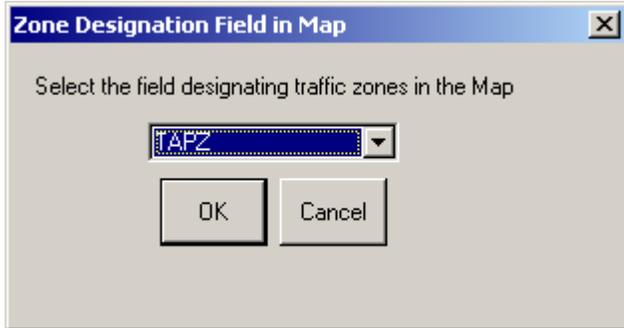
#### Step 21-1. Region Name and Map

Enter the name of the region and the full path of the TransCAD map file for the region in the Region Name and Map dialog box. Click on **Browse** to navigate to the location of the map file and then Click on **Open**. Click **OK** when done.



### Step 21-2. Zone Designation

Select the field that represents the traffic zone unit being used in the Accessibility analysis in the Map file just chosen. Click **OK** when done.



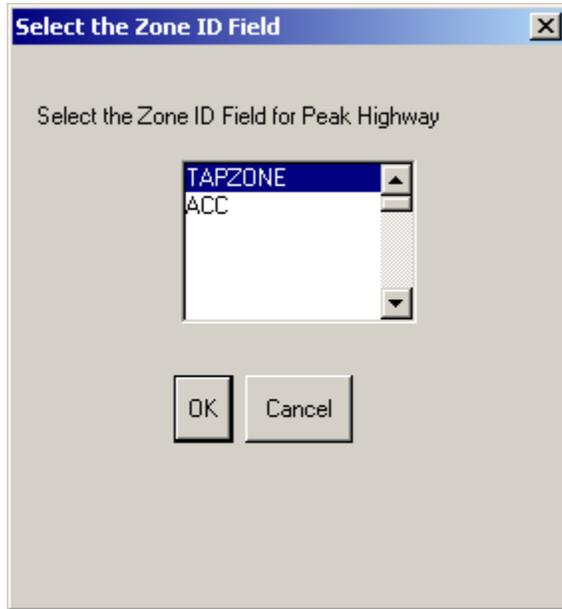
### Step 21-3. First Data File to be Compared

In the dialog box first give a descriptive name of the first file to be compared (example: **Peak Highway**). In the second box enter the full path of the first dBASE file that you wish to compare. This file will be the output of a previous Accessibility run. Use **Browse** to navigate to the file if necessary. Click **OK**.



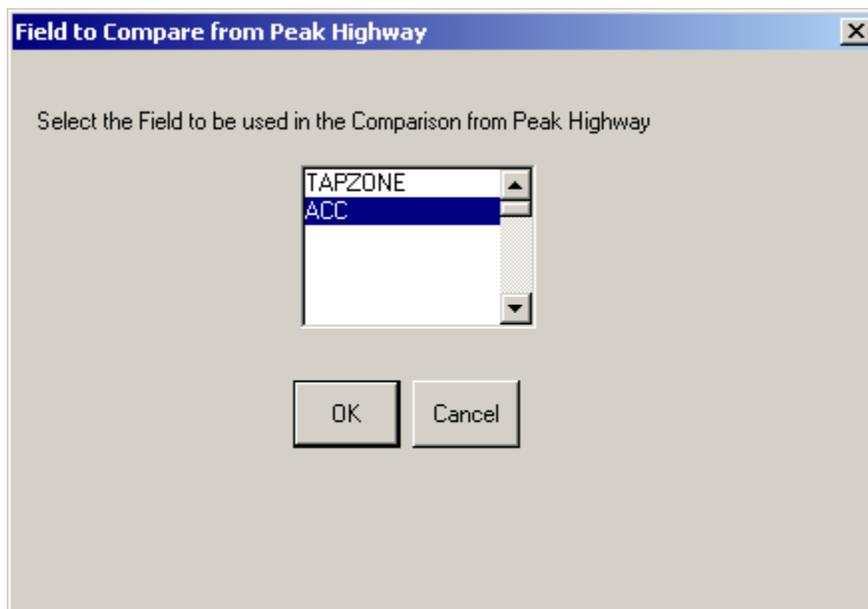
#### Step 21-4. Select the Zone ID Field

Select the field that identifies each traffic zone unit in the data file selected in step 21-3 from the scroll list. Click **OK**.



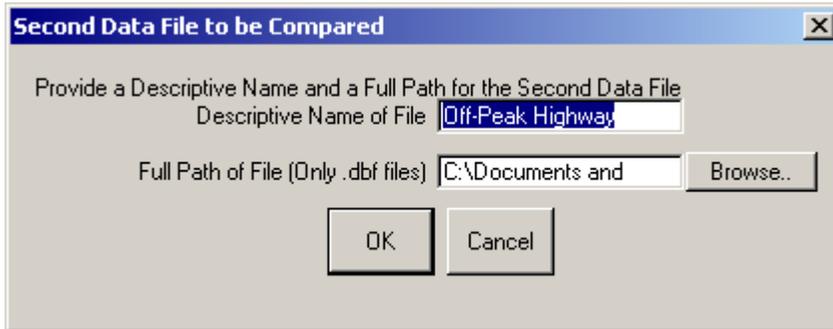
#### Step 21-5. Field to Be Compared

Select the field that needs to be compared from the same file. Click **OK**.



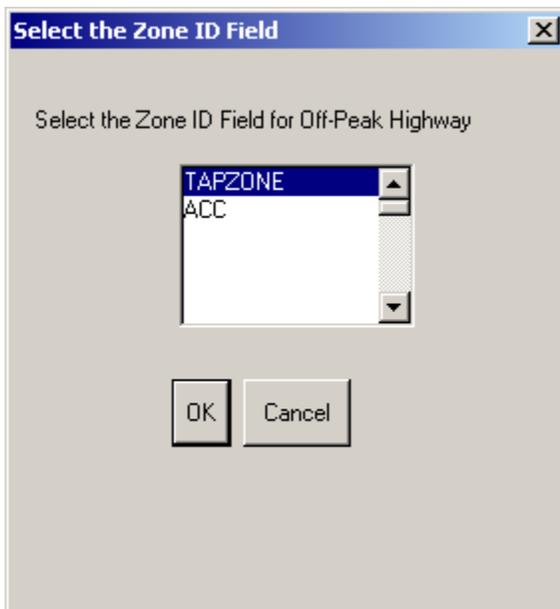
### Step 21-6. Second Data File to be Compared

In the dialog box first give a descriptive name for the second file to be compared (example: **Off-Peak Highway**). Next, enter the full path of the second dBASE file that you wish to compare. This file will be the output of another previous Accessibility run of the software. Use the **Browse** button to navigate to the file if necessary. Click **OK**.



### Step 21-7. Select the Zone ID Field

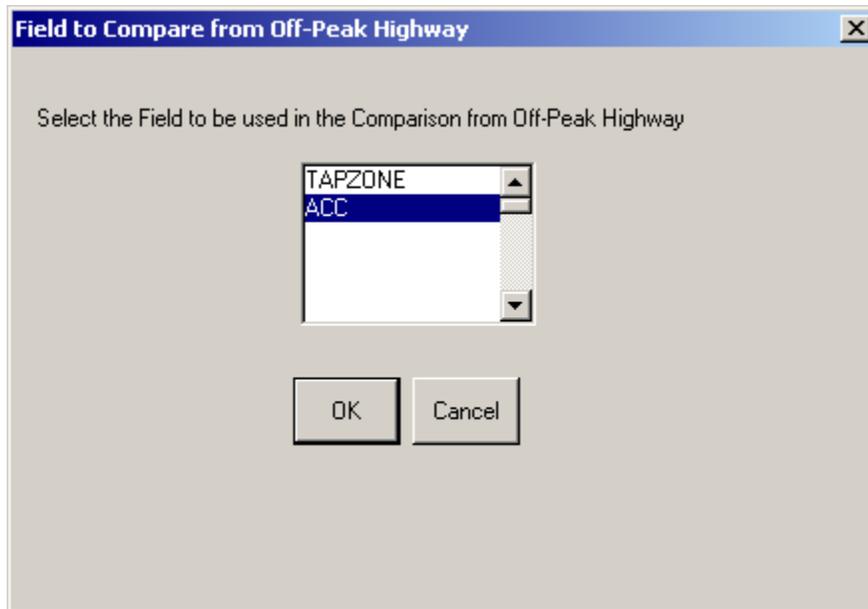
Select the field that identifies each traffic zone unit in the data file mentioned in step 21-6 from the scroll list. Click **OK**.



### Step 21-8. Field to Compare

Select the field that needs to be compared from the same file mentioned in step 21-6.

Click **OK**.



The map produced is color-coded in the same way as the output map talked about in chapter 20. The comparison subtracts the values of the second file from those of the first. Hence a negative value indicates that the comparison field in the second file is greater than the field in the first file. So, you must be careful when viewing the map if your interest is only in the absolute difference of values.

